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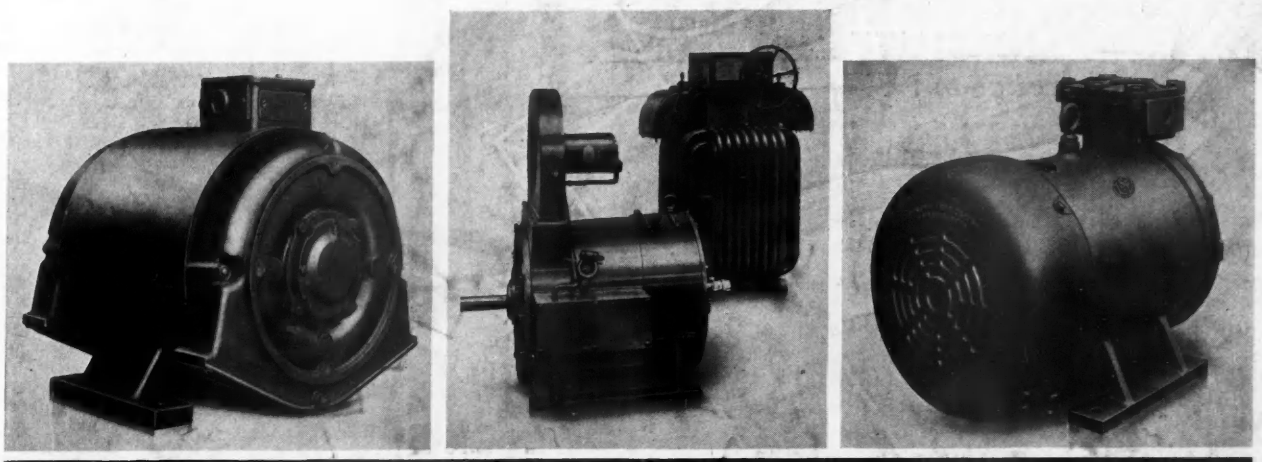

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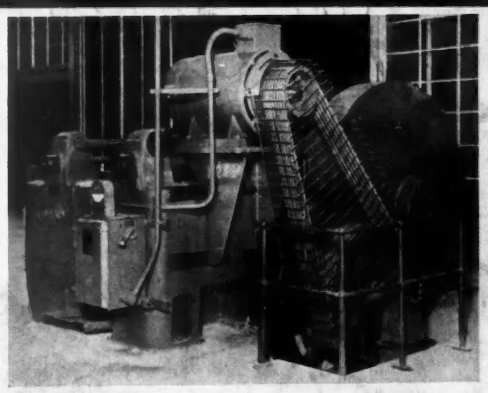

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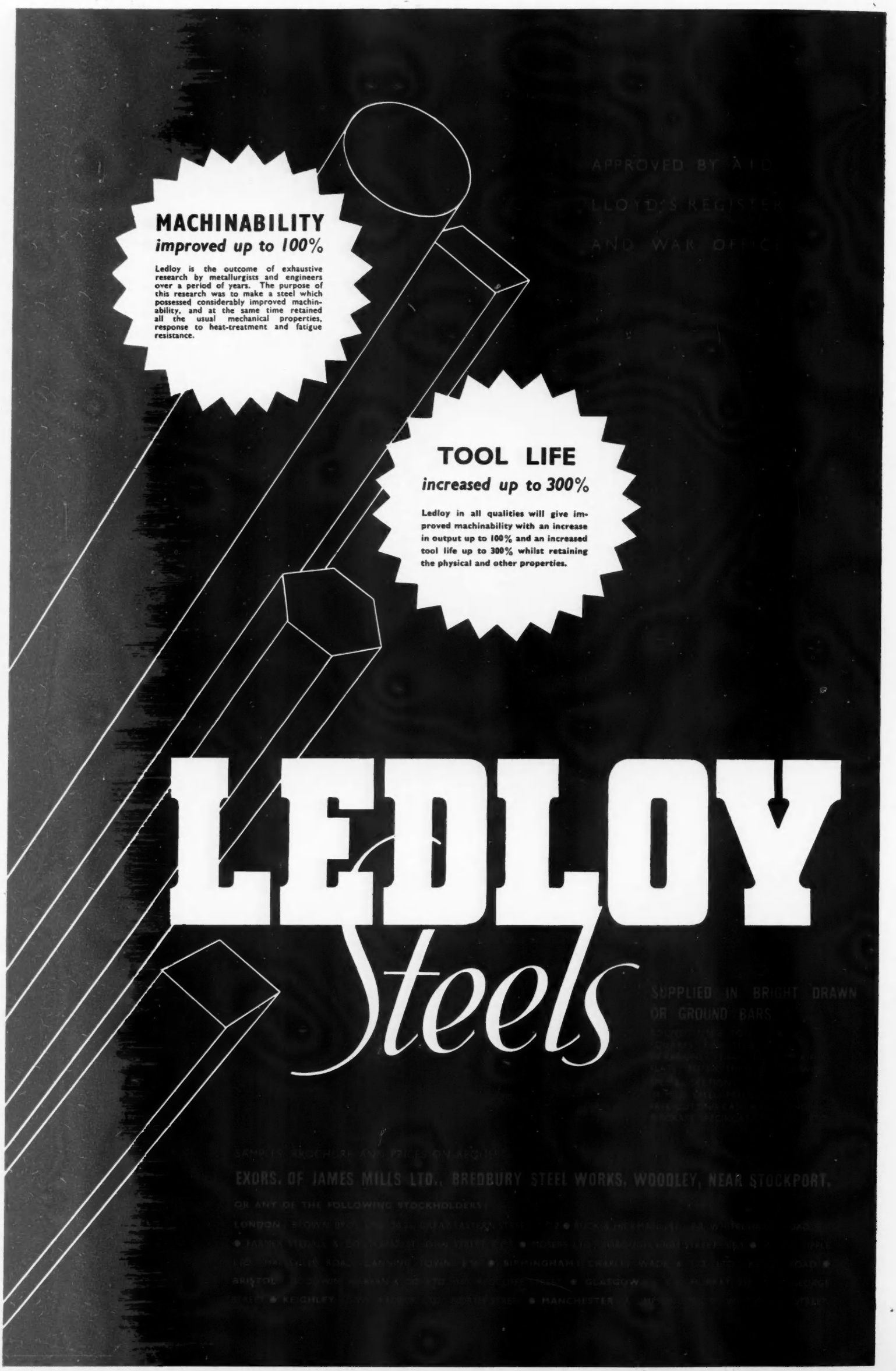
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A Seven-Day Journal

The Metropolitan Water Board

THE Metropolitan Water Board met on Thursday, May 9th, under the chairmanship of Sir William Prescott, and reviewed the work of the three years for which the Board is elected. Sir William was able to announce that the Treasury had officially sanctioned the completion of the two new reservoirs at Chingford and Staines, and the new pumping station at Hampton, which when finished will be the finest of its type in the world. It will be recalled that when war broke out, there was correspondence between the Board and the Minister of Supply, with regard to the completion of the Chingford, Staines and Walton reservoirs, and it was decided by the Board to terminate the work on the Walton reservoir. In reply to the notice of the Minister that he intended to exercise compulsory powers, with a view to utilising on work of national importance a considerable portion of the excavating plant then engaged on the construction of the Chingford and Staines reservoirs, the Board made strong representations to the Ministry, urging the imperative need for the completion of both the Chingford and Staines reservoirs as soon as possible. While insisting that the excavating plant should be placed at the disposal of the contractor, to be used as the Minister might direct, it was stated by the Ministry that the operations at the reservoirs would be interfered with as little as possible. The work of completion is now to be proceeded with. With regard to the future supply of water in London, Sir William stated that a special sub-committee of the Board has been set up to deal with this important matter. There was need, he said, to look forward for some twenty-five years. Meanwhile during the next few years there would be installed at a reasonably low cost the most modern and scientific system of water purification ever known. In reply to a vote of thanks, Sir William said that the Board could congratulate itself on having done its part by taking vigorous steps in good time, in order to protect London, as well as could reasonably be expected, from a contaminated and crippled water supply.

Brighton Centenary Railway Exhibition

ON May 11th, 1840, one hundred years ago, two important events connected with railway progress at Brighton occurred. They were the inauguration of the Brighton Central Railway Station, and the making of the first journey on the branch line from Brighton to Shoreham. At that time the main Brighton line was under construction, but there were no trains running between Brighton and London until the following year. In order to celebrate these two events the Southern Railway Company arranged, in collaboration with the Brighton Corporation, a small but nevertheless interesting exhibition at the Royal Pavilion Brighton which remained open until Wednesday, May 15th. The exhibition was formally opened on Tuesday, May 7th, at a ceremony at which many persons connected with railway interests in the south were present. In the unavoidable absence of Mr. E. J. Missenden, the General Manager of the Southern Railway Company, the chair was appropriately taken by Mr. C. Grasemann, the Public Relations Officer of the Company, who spoke of the traffic that passed through Brighton Station as something phenomenal throughout the world. The Mayor of Brighton, Councillor J. Talbot Nanson, replied. In the main, the exhibits consisted of prints and photographs showing the station, the Shoreham line and various other features connected with the railway as they existed in 1840 and as they are to-day. There were also photographs of the interior of the station at different periods, along with prints and photographs of the New England cutting at various stages, panoramic views of the Brighton Works and Station at different periods, and similar pictures of the Portslade, Southwich and Shoreham Stations. Of special interest was a specimen of the flat disc signal of a hundred years ago. Among those who lent prints from their collections may be mentioned Mr. W. H. Blaber and Mr. J. S. North.

The British Mercantile Marine

IN the course of a speech which he made at the 83rd annual meeting of the Mercantile Marine Service Association, held at Liverpool on Tuesday, May 7th, Sir Arthur Salter, the Parliamentery Secretary of the Ministry of Shipping, said that after eight months of war, fought principally on the sea, our Merchant Navy, with the additions made to it was virtually intact. By building ships, and by capturing enemy vessels we had at the present time within less than one per cent. the tonnage which we possessed when the war started. It was necessary, however, Sir Arthur stated, that we in this country should make an effort to build as many ships as possible, and at the same time economise as far as possible in the use of tonnage. Our merchant ships, he pointed out, were themselves instruments of war, and we needed for the struggle in which we were engaged every instrument of war. He expressed the hope that after the war the nation would not forget, as sometimes it had forgotten, how much this country depends on its mercantile marine. In another speech made at the Mansion House on Tuesday, May 8th, at the annual meeting of the British Sailors Society, Mr. R. S. Hudson, the Minister of Shipping, said that one of the miscalculations which the enemy made was his belief that he could break the spirit and morale of the men of the Merchant Navy or for that matter of the men of the neutral merchant navies. During the long winter nights and days the men of the mercantile marine had kept their tryst and had held the seas. The story of those months of endurance, of undaunted courage and hardship, had been told in part, but part would never be told unless the sea gave up its dead. On behalf of the Ministry of Shipping, Mr. Hudson expressed his thanks to the British Sailors Society, whose history, he said, went back to a century and a quarter ago, and to kindred associations for the work they had done.

L.M.S. Derby Works Centenary

DERBY celebrated its hundredth birthday as a railway manufacturing town on Saturday, May 11th, when the centenary occurred of the establishment there of what are now the L.M.S. Railway works, one of the largest centres in the country for the manufacture and repair of locomotives, carriages and wagons. To-day the works cover a total extent of 175 acres and give employment to more than 8000 people, but originally they comprised a small group of buildings for use of the North Midland and Midland Counties Railways, which with the Birmingham and Derby Junction Railway shared the use of Derby passenger station, opened at the same time as the works. The North Midland Railway, engineered by George Stephenson, was opened from Derby to Rotherham, with connection from Rotherham to Sheffield, on May 11th, 1840, whilst the Midland Counties Railway, which had been opened from Nottingham to Derby in the previous year, was extended to Leicester on May 4th, 1840. The first Locomotive Superintendent at Derby was Robert Stephenson, son of "the father of railways"; he held office on behalf of the North Midland Railway from 1841–44 when the whole of the railway establishment at Derby came under the ownership of the Midland Railway, which was formed in that year by amalgamation of the North Midland, Midland Counties and Birmingham and Derby Junction Railways. During the past 100 years the works have been several times enlarged and modernised to meet increasing demands, the most extensive alterations being those of 1873 when the locomotive and carriage works were separated and re-equipped throughout. Despite successive modernisations, some of the original engine houses and other buildings are still in use for various purposes, but the most historic relic connected with the works is the bell of the turret clock in the Locomotive Offices; it bears the date 1717 and is still in use. It is believed that this bell was taken from the old St. Pancras chapel, London, when the chapel was demolished about 1865 in connection with the building of St. Pancras Station. The clock itself is 100 years old, having been made in 1840 by Whitehurst, of Derby, and every care is being taken by the L.M.S. authorities to keep it in good working condition for ultimate preservation as an historic relic.

Health in an Engineering Works

IN recent issue of *Industrial Welfare* a medical officer of an engineering firm which employs 20,000 workers gives an account of their general health during the first six months of the war. The lessons of the last, war, he says, have been learned, and if they are not applied in full they are at least preventing such evils as the ninety-hour week. With the improvements which have been effected in welfare work and the wide field now covered by the Factory Acts there is now no reason why serious and outstanding effects on the health of people working in engineering factories should occur. The accident and the general sickness rates both fell very much during the first three months of the war, mainly because large numbers of workers were suspended through A.R.P. work and the change over to war production. The accident rate afterwards rose and is still rising. Many of these accidents were directly attributable to the blackout and were caused by falls and collisions with walls and other objects. So far nothing has occurred to suggest any general increase in functional nervous disorders. A few special groups, however, have shown an increase in nervous symptoms. It has been most noticeable among the senior members of the staff, more particularly shop superintendants. Some of these men have had the responsibility of a completely altered shop layout with different machines, and different articles to produce. They have had many new employees and in addition they have been endeavouring to supervise a night shift as well as a day shift, often working seven days a week in order to get things going. Several have shown marked anxiety states and others signs of chronic fatigue. Beyond the interference with ventilation the blackout does not seem to have caused much trouble other than a certain amount of depression. No increase in eyestrain has been noticed, a fact which it is stated must be taken as a tribute to the excellent artificial lighting provided. There was an increase in the risk of industrial poisoning due to longer hours worked by lead workers and accumulator plate pasters and the working hours have now been much reduced.

Shipbuilding in Canada

ACCORDING to the latest information received from Canada, the ship construction programme in that country is proceeding well ahead of schedule. Work is being carried on day and night at fifteen shipyards along the coasts and on inland waters. Up to date, the results obtained are such as to be especially pleasing to the Dominion officials who are supervising the work and to the officers of the British Admiralty. The work of construction, it is stated, is being carried forward at high speed. Apart from the shipyards, a variety of engineering works and manufacturing plants throughout the Dominion are now working to capacity on shipyard orders, which range from raw materials and sem-finished articles in steel, bronze and timber to completed products such as boilers, engines, pumps, cables and other engineering equipment. It is reported that at present some 4000 men are engaged in the work, and that their numbers will shortly be more than doubled. The present two-year programme calls for the construction of more than 100 vessels for naval and air force purposes. These ships include 64 patrol ships and 26 minesweepers. Several of the larger ships are well advanced in construction, and are to be delivered this year, while othere are scheduled for completion early in 1941. The vessels which are now in course of completion are required for the defence of local waters, for general service with the Royal Canadian Navy, for the Royal Navy, and as service boats with the Royal Canadian Air Force.

Naval Losses in Norway

THE naval losses in the withdrawal of troops from Namsos in Norway include the British destroyer H.M.S. "Afridi," the French destroyer the "Bison" and the Polish destroyer "Grom"; also six British trawlers. The "Afridi" was commanded by Captain P. L. Vian, D.S.O., who was in command of the destroyer "Cossack" which recently rescued 300 British prisoners from the German armed auxiliary "Altmark." Captain Vian is happily among those who were rescued from the "Afridi" when she was sunk in conveying troop transports off the coast of Norway. She was attacked by waves of bombers, and was struck by bombs and subsequently sank. The "Afridi" was a destroyer of the "Tribal" class and was constructed on the Tyne by Vickers-Armstrongs, Ltd., in 1938. She had a displacement of 1870 tons, and her leading dimensions were 355ft. 6in. by 36ft. 6in. by 9ft. She carried eight 4·7in. guns and seven smaller guns, and four 21in. torpedo tubes. She was propelled by Parsons geared turbines, taking steam from three Admiralty boilers of the standard three-drum type. Her machinery had a designed output of about 44,000 S.H.P. and her designed speed was 36·5 knots. The "Bison" was a ship of the Guepard class and was built by Lorient and completed in 1930. She had a displacement of 2436 tons with a length of 427ft., a beam of 39ft. and a depth of 16ft. 9in. Her armament comprised five 5·5in. guns and four 37 mm. guns with six torpedo tubes. Her propelling machinery consisted of Parsons geared turbines and water-tube boilers giving a total output of 64,000 S.H.P., corresponding to a speed of 36 knots. The "Grom" was built and engined by John Samuel White and Co., Ltd., Cowes, in 1936, and had a displacement of 2144 tons, with a length between perpendiculars of 257ft., a beam of 37ft. and a depth of 10ft. 6in. She was armed with seven 4·7in. guns and four 47 mm. guns, and carried six 21in. torpedo tubes arranged in triple mountings. The machinery comprised an arrangement of Parsons geared turbines on two shafts, having a designed output of 54,000 S.H.P. and taking steam from four three-drum boilers, working at a boiler pressure of 385 lb. with 200 deg. of superheat. The bows of the destroyer were specially strengthened for ice navigation. The trawlers which were sunk or had to be abandoned included H.M. trawlers "Warwickshire," "Cape Chelyuskin," "Jardine," "St. Goran," "Gaul" and "Aston Villa." The four ships last named were damaged by air attack and it was not deemed advisable for them to attempt the crossing of the North Sea. They were sunk by our forces.

An Investigation of the High-Speed Producer Gas Engine

By M. W. WOODS, D. Phil. (Oxon), B.E., B.Sc., A.M.I.E. Aust.

No. I

Introduction

IN a paper published in THE ENGINEER, May 26th, 1939, A. F. Burstall and the author described equipment which had been installed at the Melbourne University Engineering Laboratory for research on the high-speed producer gas engine. The experimental method which it was proposed to follow was outlined, and some preliminary results were given.

The first series of experiments, comprising engine tests on charcoal producer gas at a number of compression ratios has now been completed, and the results are here presented. The general aim of the investigation has been to make an analysis of the behaviour of producer gas in a high-speed engine, along the lines of the classical work of Ricardo (1923) on the petrol engine and Burstall's (1925) investigation of the coal gas engine.

In countries like Britain and Australia, which have little or no indigenous supplies of oil, considerations of national self-sufficiency in time of emergency compel the examination of the possibilities of the use of native fuels as a substitute for petrol and oil in road transport vehicles. Producer gas, generated from charcoal or anthracite, is one such alternative. It has, however, been pointed out by Fowke (1939), Goldman and Jones (1939), the author (1938), and others that the use of these fuels should not be regarded merely as an emergency measure, and that savings in operating costs can be made by operating engines on producer gas. Considerations such as these are not dealt with in this paper, which is concerned purely with the technical aspects of engine performance; some more practical matters relating to the conversion of petrol engines to gas operation are briefly mentioned in Appendices II and III.

Apparatus and Mode of Conduct of Tests

The engine and other equipment used for the tests have been fully described by A. F. Burstall and the author in the paper mentioned above, to which the reader is referred. The calibration of the various instruments, the mode of conduct of the tests, and the accuracy of the measurements are also discussed there, and will not be repeated here.

Tests have been conducted at compression ratios ranging from 4·91 : 1 to 15·7 : 1. The variable ratio head fitted to the engine has not been used since it does not permit of the use of an indicator.

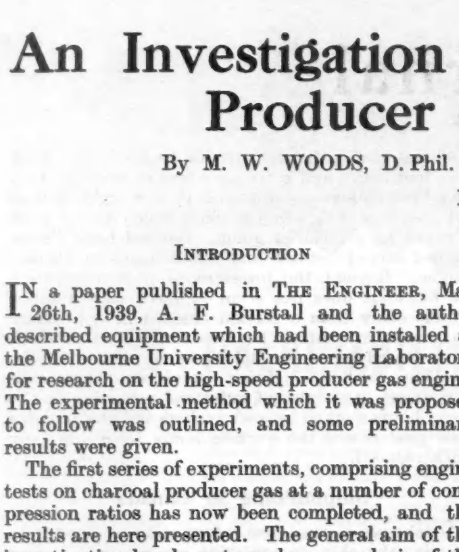


FIG. 1—EFFECT OF VARYING CO CONTENT

A number of fixed heads, some supplied by the makers of the engine (Messrs. Ricardo) and some made in the laboratory workshop, have provision for accommodating the pressure unit of the "Standard Sunbury" cathode ray indicator.

In view of the difficulty of calibrating the pressure scale of the cathode ray indicator, cylinder maximum pressures and compression pressures were measured by means of a "Farnboro'" electrical indicator. The construction of the cylinder heads made it necessary to employ a long adapter leading to the disc valve of this indicator, with a consequent reduction in the compression ratios. The volume of the indicator passages for each indicator has been taken into account in determining compression ratios.

The Heat Content of the Gas-Air Mixture

The gas used for the tests was generated in a Wishart "high-speed gas" type producer, burning charcoal made from red gum and box timber. By maintaining a constant suction on the producer, independent of the engine demand, and by close attention to the condition of the fire and the quantity of water admitted, a gas of as nearly as possible constant quality throughout the tests was obtained. Some variation in gas composition was unavoidable, consequent on variations in the composition and moisture content of the charcoal and a tendency to form clinker near the mouth of the tuyère. Gas samples were taken simultaneously with practically all test readings, and the limits of gas composition over fifty-six samples were as follows:—

CO_2, 1·0–3·8 per cent.; O_2, 0·1–0·7 per cent.
CO, 29·2–33·1 per cent.; CH_4, 0·1–0·7 per cent.
H_2, 6·8–11·7 per cent.; N_2 (by difference), 54·0–59·3 per cent.
Net calorific value, 129–142·5 B.Th.U. per cubic foot at N.T.P.

The gas analyses were made with a "Harper" apparatus, a modified form of Orsat which permits fresh samples of the reagents to be taken for each absorption. Hydrogen and methane were determined by explosion with air in the usual way. As a check on the accuracy of the analysis, the calorific value of a sample of gas was measured in the Boys standard gas calorimeter. The result agreed within less than 1 per cent. with the value calculated from the analysis.

The power developed by an engine is proportional to the product

Mixture calorific value × volumetric efficiency × thermal efficiency × mechanical efficiency.

Hence, as far as power is concerned, it is the calorific value of the gas-air mixture rather than that of the gas itself which is important. In general, as the calorific value of a gas increases, so the proportion of that gas contained in a theoretically "correct" gas-air mixture decreases. The calorific value of the "correct" mixture which depends on the product of the gas heat value and the proportion of gas in the mixture will therefore vary in less degree with changes in gas composition than will the heat value of the gas itself.

This effect is illustrated in Fig. 1, where calorific value is plotted against carbon monoxide content for a gas containing 10 per cent. hydrogen and ½ per cent. methane. The gas net calorific value rises lineally from 101 B.Th.U. per standard cubic foot for 20 per cent. carbon monoxide to 152 B.Th.U. per standard cubic foot with 35 per cent. carbon monoxide—a percentage increase of 51, based on the lower figure. Over the same range, however, the gas percentage in the correct mixture falls from 57 to 47 per cent., and the increase in calorific value of the "correct" mixture is only 14 B.Th.U. per standard cubic foot, or 24 per cent. of the value at the lower end of the scale.

It is thus seen that fairly large variations in gas heat value may be permitted with comparatively little effect on the heat value of the mixture. For the tests here described, while the gas calorific value varied between 129 and 142·5 B.Th.U. per standard cubic foot, a variation of ±5 per cent. about a mean, the change in the heat value of the "correct" mixture was only from 67 to 70·5 B.Th.U., a variation of ±2·5 per cent.

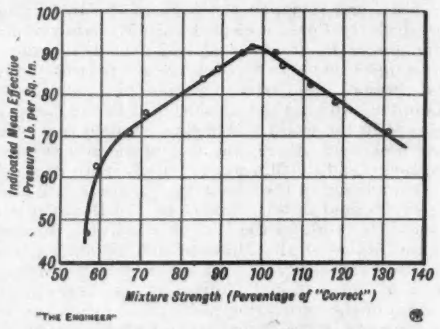


FIG. 2—POWER—MIXTURE STRENGTH CURVE

Similar considerations apply when comparing engine performance on different types of gas. In Table I typical compositions and calorific values for producer gases generated from four fuels are set out. It will be seen that as the gas calorific value rises the percentage of gas in the "correct" mixture decreases, so that the mixture heat value is not greatly affected. Figures for coal gas and petrol are included for comparison. The power developed by an engine running on the various fuels, provided that volumetric, thermal and mechanical efficiencies remain the same, will be proportional to the figures shown in the last column of the table.

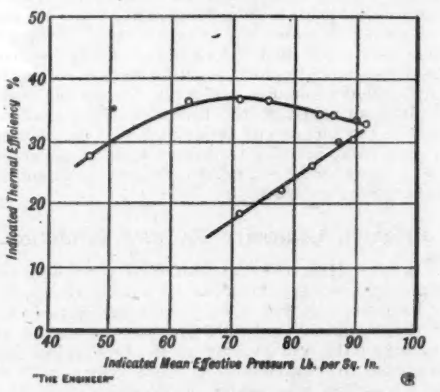


FIG. 3—EFFICIENCY—POWER LOOP

Table I

Producer and fuel.	Composition, per cent.	Net calorific value (B.Th.U. per cu. ft. at N.T.P.).	Per cent. gas in "correct" mixture.	Mixture net calorific value (B.Th.U. per cu. ft. at N.T.P.).
Wishart "high-speed gas" producer—charcoal	CO, 31; H_2, 9·5; CH_4, 0·5; CO_2, 2; N_2, 57	138	49·5	68·5
Humboldt Deutz producer—anthracite	CO, 26; H_2, 15; CH_4, 1·4*; CO_2, 4·5; N_2, 53·1	144·5	47·5	68·5
Imbert producer—wood ...	CO, 23·3; H_2, 18·0; CH_4, 1·5†; CO_2, 11·1; N_2, 46·1	145·5	47	68·5
Greig producer—brown coal briquettes	CO, 23·3; H_2, 16·1; CH_4, 3·9‡; C_MH_N, 0·35; CO_2, 6·95; N_2, 49·4	168·5	42·5	72
Coal gas—Melbourne town gas	CO, 16·0; H_2, 37·2; CH_4, 26·6; C_MH_N, 4·2; CO_2, 3·5; N_2, 11·5; O_2, 1·0	514	17·7	91
Petrol	—	—	2 (approx.)	98

* See Goldman and Jones (1939).
† See Kühne, Fischer and Koch (1932–3).
‡ These figures were kindly supplied by the Victorian State Electricity Commission.

The Effect of Mixture Strength on Power and Efficiency

Tests were conducted over the range of mixture strengths within which the engine would run steadily at each of six compression ratios and a constant speed of 1500 r.p.m. The results of the tests at the 7·93 : 1 ratio are set out in Table II and plotted in Figs. 2 and 3. The ignition advance

was adjusted to give maximum power at each mixture strength, for reasons which appear later.

The term "mixture strength" is here used to denote the strength of the mixture entering the cylinder, expressed as a percentage of the theoretically "correct" mixture determined by the equation for the combustion. It will be understood that the mixture actually in the cylinder will differ from the entering mixture on account of the mixing of the charge with the residual products from the preceding cycle. The evaluation of the actual mixture involves assumptions as to the composition and temperature of the residuals, and it is convenient to avoid such assumptions by considering only the strength of the mixture entering the cylinder. This point has been discussed by Burstall (1925).

Fig. 2 shows indicated mean effective pressure (I.M.E.P.) plotted against mixture strength, while in Fig. 3 indicated thermal efficiency is plotted against I.M.E.P. The latter diagram is analogous to the familiar "consumption loop" by which petrol engine test results are frequently expressed. It will be noted (Fig. 2) that maximum power was attained with a mixture 2 per cent. weaker than the theoretically correct. Indicated thermal efficiency was 33·4 per cent. at the point of maximum power, and reached a maximum of 37·3 per cent. at a mixture strength about 66 per cent. of the correct. The attainment of maximum power with a slightly lean mixture is most perplexing, and the author has not yet arrived at any satisfactory explanation. Neglecting dissociation, it would be expected that maximum power would be reached with the "correct" mixture.

Tizard and Pye (1923) have shown that, for the petrol engine, when dissociation is taken into account, maximum power is attained with a mixture 20 per cent. rich, and this conclusion is amply borne out by experimental results. The author has made a similar analysis for producer gas, taking account of the CO_2-CO-O_2 and H_2O-H_2-O_2 dissociations (see Appendix I) and the results indicate that maximum power should be reached with a mixture 2 per cent. rich. A further analysis, taking into account the formation of nitric oxide, gives approximately the same value for the maximum power mixture. It appears that one must look elsewhere, either to further dissociations or to some other phenomenon, for an explanation of the observed result.

The plotted points cover the whole range of mixtures within which the engine would run satisfactorily. It is believed that the lower limit—about 56 per cent. of the "correct"—represents a true limit beyond which combustion would not take place with sufficient regularity for steady running at the speed of the tests. The irregularity of the combustion at very weak mixtures is illustrated in Fig. 4 (top), a photograph of cathode ray indicator diagrams when running on a 60 per cent. mixture at a compression ratio of 5·86 : 1 and a speed of 1500 r.p.m. The time of exposure covered a number of engine cycles, which may be seen individually, ranging from a complete miss to a full explosion. It will be noted that, in some cases, combustion took place after a greatly lengthened delay period. Ignition was at 43 deg. before top dead centre. For comparison diagrams photographed (with a shorter exposure) at the same speed and compression ratio, but with approximately the maximum power mixture, are reproduced in Fig. 4 (below).

The upper limit to the mixture strength—about 130 per cent.—was set by the increasing difficulty of controlling the engine. A gas engine, when running on a mixture of air supplied at atmospheric pressure and gas supplied under a slightly greater pressure (in this case 2in. W.G.), is inherently unstable at rich mixtures. A slight increase in speed has the effect of weakening the mixture, with a consequent further acceleration. It was found necessary to maintain continual manual control on the mixture strength in the rich range.

It will be noted that the power-mixture strength curve is of a sharply peaked nature. This fact, which is in accordance with theory, indicates that close control of mixture strength is necessary if maximum power is to be developed. Further, in a multi-cylinder engine, the induction system must be so designed that each cylinder receives precisely the same mixture; differences of the order of ±10 per cent. in the mixture strength which are tolerated in the petrol engine, where the effect on power is small, would lead to serious power loss in the gas engine.

TABLE II.—*Effects of Varying Mixture Strength; Ignition Advance Set for Maximum Power at Each Mixture Strength; Compression Ratio, 7·93 : 1; Fuel, Charcoal Producer Gas. (Barometer, 29·90in.; Air Temperature, 82–85 Deg. Fah.; Humidity, 50 Per Cent.)*

Test No.	Gas, cu. ft. per min. at N.T.P.	Air, cu. ft. per min. at N.T.P.	Mixture strength, per cent. "correct."	Gas calorific value (net), B.Th.U./st. cu. ft.	Speed, r.p.m.	Spark advance (deg. before T.D.C.).	Point of max. pressure (deg. after T.D.C.).	"Combustion time" (deg. of crank angle.)	Indicated mean effective pressure, lb. per sq. in.	Mechanical efficiency, per cent.	Volumetric efficiency, per cent.	Indicated thermal efficiency, per cent., based on gas consumed.
H.4.5	2·01	5·18	56·5	141	1490	37	16	53	46·8	55·3	79·2	27·8
H.4.4	2·08	4·93	59	138·5	1485	37	18	55	62·5	67·9	77·5	36·5
H.4.3	2·34	4·62	67	138·5	1500	33	19	52	70·6	72·7	76·1	36·9
H.4.2	2·57	4·40	71·5	136	1500	29	19	48	75·7	75·6	76·2	36·8
H.4.1	2·88	4·01	85	142·5	1500	23	20	43	83·6	76·4	75·4	34·6
H.3.1	3·07	3·86	89	138	1495	24	18	42	86·0	76·3	76·0	34·3
H.3.2	3·20	3·64	95	141·5	1495	20	20	40	90·0	78·0	75·1	33·6
H.3.3	3·26	3·56	97	141·5	1480	18	20	38	91·2	77·8	75·6	33·1
H.3.4	3·44	3·38	102	141·5	1480	19	19	38	89·1	78·1	75·6	30·7
H.3.5	3·51	3·30	104·5	141	1505	22	18	40	87·1	78·0	74·3	30·0
H.3.6	3·72	3·04	111·5	142	1480	23	17	40	82·5	76·0	75·0	26·2
H.3.7	4·00	2·82	118·5	142·5	1475	25	16	41	77·7	75·3	75·9	22·8
H.3.8	4·48	2·48	130·5	142·5	1485	25	20	45	70·8	71·4	76·9	18·6

Limits of Gas Composition.—CO_2, 1·0–2·6 per cent.; O_2, 0·2–0·7 per cent.; CO, 30·5–33·1 per cent.; CH_4, 0·1–0·4 per cent.; H_2, 8·2–11·4 per cent.; N_2, 54·0–56·8 per cent.; net calorific value, 136–142·5 B.Th.U. per cubic foot at N.T.P.

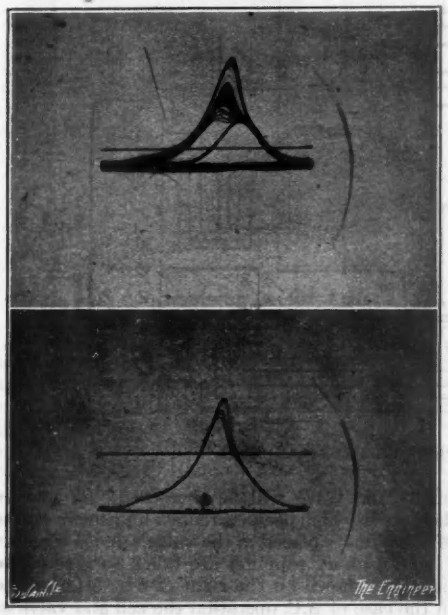


FIG. 4—INDICATOR DIAGRAMS FOR LEAN AND MAXIMUM POWER MIXTURES

THE EFFECT OF COMPRESSION RATIO ON POWER AND EFFICIENCY

Curves similar to those of Figs. 2 and 3 for the whole range of compression ratios from 4·91 : 1 to 15·7 : 1 are plotted in Figs. 5 and 6. The tests were conducted under widely varying atmospheric conditions; for the purpose of comparison the mean effective pressures have been corrected to correspond with the changes in volumetric efficiency which would have eventuated if all tests had been conducted under standard conditions (30in. of mercury, 60 deg. Fah., saturated).

In all cases maximum power was reached with mixtures between 97 and 99 per cent. of the

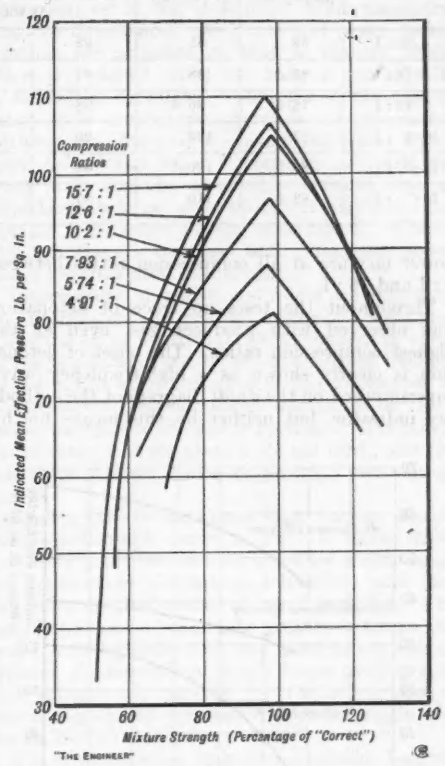


FIG. 5—POWER—MIXTURE STRENGTH CURVES

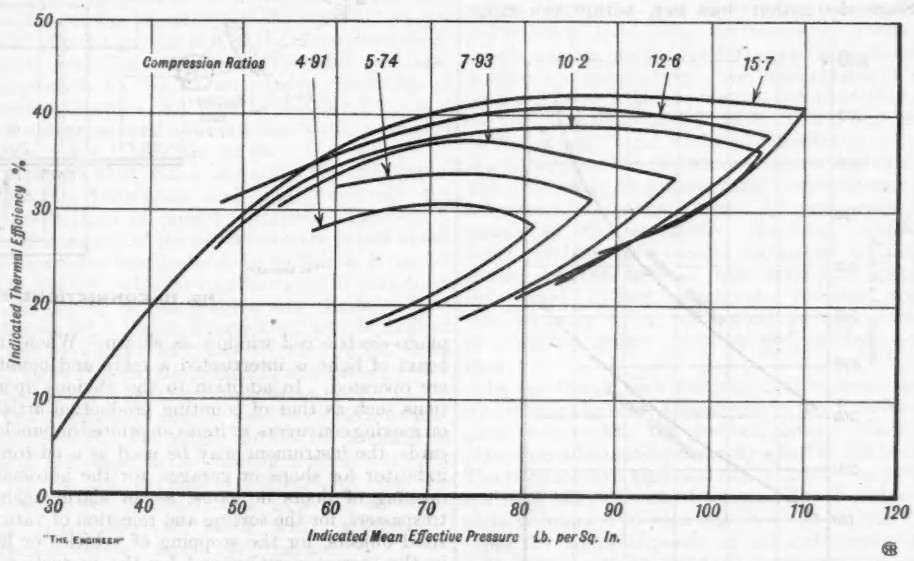


FIG. 6—EFFICIENCY—POWER LOOPS AT VARIOUS COMPRESSION RATIOS

theoretically "correct." No systematic change in the maximum power mixture was detected as the compression ratio was increased.

The principal results of the tests at each compression ratio are set out in Table III. Full sets of readings, similar to those of Table II, are available for each compression ratio.

In Fig. 7 maximum indicated mean effective pressure and indicated thermal efficiency at the point of maximum power are plotted against compression ratio. The air standard efficiency is also shown, for comparison with the latter

curve. The efficiency ratio, or ratio of indicated thermal efficiency to air standard efficiency, lies between 0·60 and 0·61 at the maximum power mixture at all compression ratios between 6 : 1 and 16 : 1.

Throughout the tests no trace of detonation was observed with producer gas, even at the highest compression ratios. The onset of detonation is clearly shown as a high-frequency wave superimposed on the dp/dt diagram of the cathode ray indicator, but neither by this means nor by aural observation was detonation detected. In this connection it is of interest to record that coal gas, generally regarded as a non-detonating fuel, detonated readily at a compression ratio of 12·6 : 1. The knocking was not of great intensity, and could be practically eliminated by retarding the ignition.*

Since detonation does not, within the range of the experiments, set a limit to compression ratio, one must turn to cylinder pressures to define this limit. Compression pressures and maximum combustion pressures at various compression ratios are tabulated in Table IV and plotted in Fig. 8. It will be noted that, at a compression ratio of 14·8 : 1, the maximum pressure was 900 lb. per square inch. The extreme pressure limit allowable in an engine cylinder, according to present-day practice, is about 1000 lb. per square inch.† With the producer gas engine this value would be reached at a compression ratio between 15 : 1 and 16 : 1.

It would appear that, if the point of ignition is to be chosen to give maximum power (and, hence, maximum efficiency) at the maximum power mixture, the compression ratio must be limited to 15 : 1. If this ratio is exceeded, it is necessary to retard the ignition, as is the usual practice with the compression ignition engine, in order that the maximum pressure will not exceed 1000 lb. per square inch. This procedure involves a drop in efficiency which largely nullifies the gain consequent on the increased compression.

(To be continued)

TABLE III.—*Principal Results of Tests at Various Compression Ratios*

Fuel, charcoal producer gas; ignition advance set for maximum power throughout; mean effective pressure and volumetric efficiency corrected to standard atmospheric conditions (30in. mercury, 60 deg. Fah. saturated).

Compression ratio.	Maximum brake mean effective pressure (lb./sq. in.).	Maximum indicated mean effective pressure (lb./sq. in.).	Mixture strength (per cent. "correct").	Spark advance (degrees before T.D.C.)	"Combustion time" (degrees of crank angle).	Volumetric efficiency, per cent.	Indicated thermal efficiency, per cent.	Maximum indicated thermal efficiency, per cent.
			At the point of highest mean effective pressure.					
4·91 : 1	63	81	98	26·5	48·5	79·0	28·3	30·7
5·74 : 1	69·5	88	97	25	45	79·0	31·5	34·0
7·93 : 1	75·5	96·5	98	19·5	39	79·2	33·4	37·3
10·2 : 1	82	105	99	18	37·5	79·2	36·1	38·8
12·6 : 1	85·5	106·5	98	12·5	31	77·7	37·8	40·7
15·7 : 1	89·5	110	97	10	25	77·0	40·4	42·0

TABLE IV.—*Maximum Pressure and Compression Pressure at Various Compression Ratios; Mixture Strength and Spark Advance Set for Maximum Power.*

Compression ratio.	Compression pressure, lb./sq. in. gauge.	Maximum pressure, lb./sq. in. gauge.
4·85 : 1	120	312
5·65 : 1	144	370
9·3 : 1	260	500
11·2 : 1	330	585
13·5 : 1	420	735
14·8 : 1	495	900

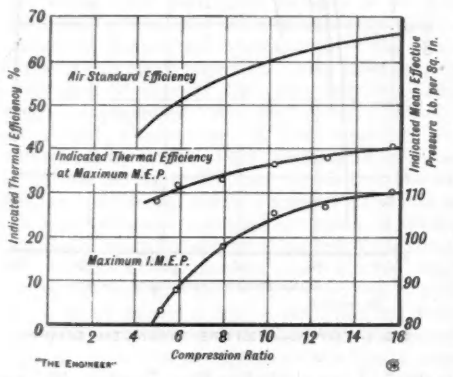


FIG. 7—EFFECT OF COMPRESSION RATIO ON POWER AND EFFICIENCY

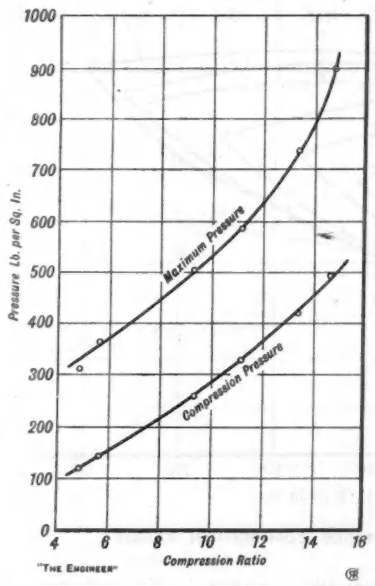


FIG. 8—EFFECT OF COMPRESSION RATIO ON CYLINDER PRESSURES

* Melbourne town gas contains a high proportion of heavy hydro-carbons (see Table I). It is probable that a gas containing less of these constituents would be less subject to detonation.

Scientific Instruments and Apparatus

No. VIII

(Continued from page 433, May 10th)

A. C. COSSOR, LTD.

SINCE the advantages of photo-electric control methods in industrial processes have acquired recognition in many quarters, a demand has arisen for a flexible self-contained light control unit such as that introduced by A. C. Cossor, Ltd., and shown diagrammatically in Fig. 71. The instrument will perform many operations which were previously carried out mechanically or by human means. It is well suited for counting, protection, alarm, and control. A feature of the instrument is that it contains its own lamp, providing a parallel beam of light which is reflected back by a mirror on to the photo-electric cell window as shown. When this beam of light is interrupted a relay and counter are operated. In addition to the obvious operations such as that of counting production articles on moving conveyors, or items on printed or punched cards, the instrument may be used as a customer indicator for shops or garages, for the automatic opening of doors or gates, as an alarm against trespassers, for the sorting and rejection of various sized objects, for the stopping of vehicles or lifts in the correct position and for the protection of dangerous machinery.

A modified form of the instrument is supplied as a light meter which may be employed for densitometry and for smoke, dust, or turbidity recording or control. The Cossor G1 photo-cell is a gas-filled thin film caesium unit. When the cathode is illuminated the resistance of the cell becomes small in comparison with the 40 megohm fixed resistance shown in the diagram, so that a positive bias is applied on to the grid of the gas discharge triode. Care must be taken when adjusting the optical system to ensure that as much of the cathode surface as possible is illuminated. If it is desired to use the cell at a distance from the unit, the connecting cable must be screened and the metal screening connected to the unit case.

The amplifier which amplifies a photo-current of one or two microamperes is caused to control about 100 milliamperes and is composed of a single valve. When the photo-cell throws a positive bias on the grid of the valve and causes it to "fire," the characteristic purple glow of the filling is seen in the tube. When starting up the unit it is important that light should not shine on the photo-cell until the valve has had at least 30 seconds for the cathode to attain its working temperature, otherwise the life of the valve will be shortened. To prevent dangerously high peak currents a limiting resistance of 200 ohms is placed in the valve's anode circuit.

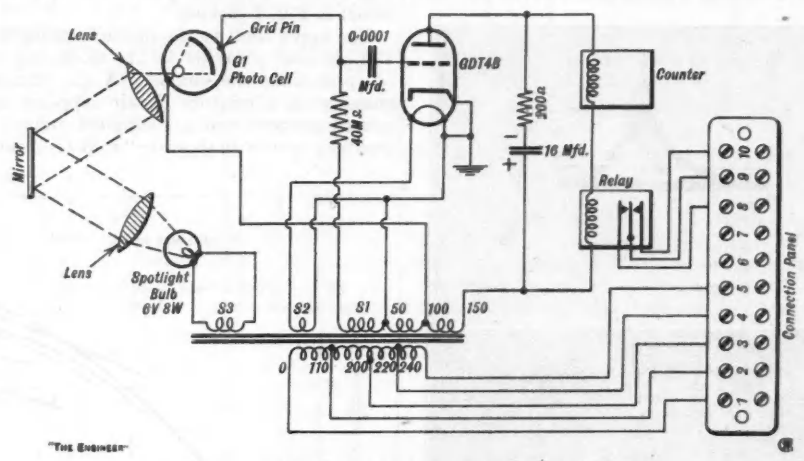


FIG. 71—CONNECTIONS FOR PHOTO-CELL RELAY UNIT

The primary tappings are taken to a connector panel, as shown on the right of Fig. 71, and since in the case of A.C. operation the cell and valve are both self-rectifying no current can flow in the reverse half cycles. The mean voltages in the various circuits are photo-cell 50 volts, valve grid 50 volts and valve anode 100 volts. Two other secondary windings supply the valve heater and the lamp.

The electrically operated counting mechanism is a small self-contained four figure counter, and the numbers can be seen through the window at the rear of the unit. With a counter winding of about 500 ohms satisfactory operation is obtained with about 60 to 70 milliamperes at 30 to 35 volts. Although the counter will operate in any position, maximum sensitivity is obtained with the figure window in the horizontal position.

The single-pole two-way relay to be seen in the diagram, Fig. 71, is designed to operate with the same current that works the counter and as the resistance is also about 500 ohms, 70 milliamperes

† See Pye, "The Internal Combustion Engine," Vol. I (1937), page 24.

at 35 volts operates it satisfactorily. Tungsten contacts will make and break up to 3 amperes at 250 volts, but if the external circuit is inductive a condenser should be used to reduce sparking. The counter and relay windings are in series and a 16 mfd. electrolytic condenser is connected in parallel with them.

Whilst the moving contact is taken to terminal No. 9 on the connection panel the other two contacts are joined to terminals 8 and 10 in such a way that when the light shines on the cell the contacts 8 and 9 are joined together, but 9 and 10 are open circuited. When the light beam is interrupted, 8 and 9 are open circuited and 9 and 10 are joined. Mechanical parts of the unit are not designed to respond to speeds greater than 5 or 6 per second.

The lamp is a high efficiency 6 volt 8 watt spot-light placed at the focal point of a short focus double convex lens, 25 mm. in diameter so as to throw a parallel beam. To obtain a good life the lamp is slightly underrun. By means of a thumb-screw the lamp may be set at the desired distance back from the lens; and also at a slight angle so that the beam is directed upon the suitably positioned mirror. The returning light beam enters through the cell windows and illuminates the photo-cell cathode. A double convex 1¼in. diameter lens increases the effective light-collecting area. In counting small objects their track is arranged so as to interrupt the beam once, and in some cases it may be preferable to employ an external light source. If when the light system has been set in position so that the cell cathode is illuminated to maximum brilliancy the valve does not "fire" the cell is either insufficiently sensitive or the light is inadequate for the distance concerned. For G 1 Cossor cells of normal sensitivity and a correctly focused light beam, the unit should operate over a total beam length of at least 10ft. If, on the other hand, the valve fails to extinguish when the light beam is interrupted the trouble may be caused either by leakage across the photo-cell or between the anode and grid of the valve.

The Cossor A.C. impedance bridge shown in Fig. 72 utilises a visual null indicator for the

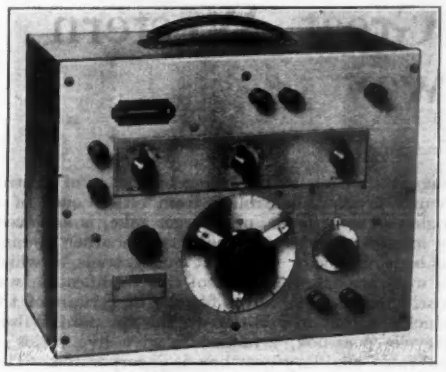


FIG. 72—A.C. IMPEDENCE BRIDGE—COSSOR

measurement of resistances, inductances and capacities, power factor and leakage. Designed for use in conjunction with the firm's double beam oscillograph, Model 3339, Fig. 73, it is directly calibrated over the following ranges—condensers 300μ F—100$\mu\mu$ F; Resistances, 40 MΩ —½Ω; Inductances, 300H—1·1 mH. This A.C. instrument uses the inertialess two-dimensional recording features of a cathode ray tube as a visual indicator for the measurement of impedance to a commercial accuracy over a wide range of values. Various notable advantages are said to be possessed by the instrument over those used previously. These advantages are (1) Repeated readjustments of the controls to obtain balance is unnecessary, because the positive or negative nature of the off balance is apparent instantly. This ensures very rapid testing. All the controls can be operated simultaneously. (2) With the cathode ray tube as an indicator, overload will not damage or affect the performance of the instrument. (3) All null methods call for maximum sensitivity at zero point where most indicators are least effective, but with this instrument the effect is offset by increasing the gain of the oscillograph amplifier which can go beyond that required for accurate determination. (4) The balance controls provide for the simultaneous reading of impedance value and power factor. (5) The trace obtained will show instantly whether the component under test is subject to intermittent faults or obscure variational effects which no conventional tester having appreciable inertia can indicate. (6) The action of the controls is more definite than is usual with null indicators, the null point being critical, which favours greater rapidity and accuracy in testing. (7) While the absolute accuracy of the instrument is dependant on the calibration of the resistance of the variable arm and its scale, the comparative accuracy is said to be very much higher and better than 0·1 per cent. which makes the instrument ideal for rapid production, testing and selection and provisions are made in the instrument to make use of this valuable feature. (8) Harmonics in the 50-cycle signal used for energising the bridge do not interfere with the accuracy of the instrument as they do with other methods.

A selector switch sets the instrument for resistance, capacity or inductance tests and an eight position multiplier switch is fitted with its successive ratio steps multiples of ten. The variable scale is calibrated over a range of 30 times.

For leakage tests a D.C. supply is incorporated for the neon tube used for such tests and the length of glow shows the magnitude of leakage. A large dial with a 6 to 1 slow motion drive has three

FIG. 73—OSCILLOGRAPH—COSSOR

scales directly marked for resistance, inductance and capacity. Over the greater part of the range the calibration accuracy is better than ± 2 per cent. and the reading accuracy of the scale is $\pm \frac{1}{2}$ per cent. On the greater part of the range discrimination is very high and better than 0·1 per cent. Components having values outside the limits of direct calibration can thus be measured by sum and difference methods to a reasonable degree of accuracy, *e.g.* C. to a few $\mu\mu$ Fs.

By adjusting simultaneously the non-interdependent impedance and phase controls the bridge balance is rapidly obtained. The A_1, X and E terminals of the instrument are joined to the corresponding terminals of the oscillograph (model 3339, Fig. 73), with its amplifier gain at maximum in the Y_1 Y_2 switch position and the time base switched off. The component on test is applied to the impedance terminals on the bridge. Two such pairs of terminals Z_1 and Z_2 and a change over switch are provided for comparative tests.

The instrument can be used with any oscillograph provided the phase shift of its amplifier is within the range of the phasing control, but even if this is not so phase compensation can be provided by an additional external network. The instrument can work with headphones, galvanometer or "magic eye" indicators.

For energising the bridge use is made of the 50 cycles per second main supply, the out-of-balance component of which is applied through the oscillograph amplifier to the Y plate of the cathode ray tube, giving vertical deflection. A similar 50-cycle signal is applied through a separate adjustable phase shifting network to the X plate of the tube and provides a horizontal deflection of approximately constant width. The adjustment of this network serves to balance the inherent bridge and amplifier phase displacements. With the bridge unbalanced both as regards impedance and phase, the resultant elliptically shaped trace is tilted either to the left or to the right, according to the direction of out-of-balance. With appreciable out-of-balance or excessive amplifier gain the ends of the ellipse may distort or become parallel to the X axis.

Impedance balance is indicated when the trace, whether straight line or elliptical, is horizontal, whilst the phase condition is shown by the width of the figure when horizontal. When measuring resistance, only the impedance and phase controls are used, the power factor control being inoperative. Correct phase control setting should produce a straight line whether the trace be horizontal or tilted either way by 30 deg. to 40 deg. When measuring reactive impedances, the phase and power factor controls are adjusted so that a sensibly linear trace is retained when the balance control tilts it above the horizontal. Contrary to the case of other null indicators there is discrimination between the effects of the phase and power factor controls. If the latter is correctly adjusted the trace will close to a sensibly straight line at impedance balance, even though it may open out because of incorrect phasing when tilted. When a different effect is obtained both phase and power factor controls need adjustment.

Intermittent or variational faults are shown by an intermittent or gradual tilting of the figure when the effect is attributable to changes in value of the component and by an intermittent opening of the figure when the effect is due to changes in power factor. Simultaneous variations in both cause the figure to tilt and to open out. The power factor range is 5 per cent. to 25 per cent., and the maximum leakage 2 megohms with a test voltage of 200.

Coming now to the Cossor high vacuum double beam oscillograph shown in Fig. 73 (model 3339) this instrument has been designed for a wide range of applications, including television, and the simultaneous indication of two variables. The use of the double beam tube greatly increases the scope and versatility of the instrument which remains a conventional single beam oscillograph, this being made possible by the advantage of interchangeability possessed by Cossor single and double beam tubes.

A 4½in. cathode ray tube is used not only because by providing double the area of the more usual 3in. diameter tube the instrument is more useful for serious work, but because each trace of the 4½in. double beam tube is 50 per cent. larger without overlap than the single trace on the 3in. tube at maximum width. The Cossor double beam oscillograph is claimed to provide the complete solution of the problem of simultaneous investigation of two independent phenomena on a common axis and is said to be preferable to the electronic switch method usually employed, not only by reason of the absence of phase delay and frequency limit but also on the score of simplicity and cost.

The instrument uses the original Cossor hard valve linear time base, the frequency range of which extends beyond 200,000 cycles and provides positive synchronisation. The two amplifier valves used can be arranged to operate independently on each Y plate or in cascade with either a high gain (4000) or wide band width (2,500,000 c.p.s.). In the latter case the performance more than covers the full video frequency range requirements of television. Amongst other features may be mentioned the automatic frequency compensated amplifier gain control, automatic brilliancy control of the spot at high time base speeds, time base flyback black-out, deflector coils, the provision of a calibration voltage, double mu-metal magnetic shielding and tandem controls.

In the Cossor high vacuum double beam tube a screening electrode placed within the Y deflector plate zone splits the focused beam. Each Y plate thus affects independently a half of the beam. The two traces though electrically in phase are thus spatially 180 deg. out of phase. The X deflector plate is common to both beams. The SB and DB tubes are interchangeable in the instrument and both types can be operated symmetrically and asymmetrically without distortion, because both are corrected for trapezium effect.

The instrument is also claimed to be outstanding in the performance of amplifiers. Two high slope (11mA/v) 16 watt pentodes are used, and a single control provides the following positions:—(1) and (2) D.C. or A.C. working direct to tube Y plates either from the front or rear panel terminals. Amplifiers disconnected. (3) Each valve applied separately to the two Y plates on the DB tube, thus enabling symmetrical input and output, SB operation (4 and 5). The two valves in cascade on a single Y plate for both the SB and DB tube, arranged for either "high gain" or "wide band" operation.

The amplifiers have independent input terminals and gain controls, the latter being designed to reduce the frequency non-linearly as the gain is reduced and impose a sensibly constant load on the input source over the entire range.

The original Cossor valve linear time base is used, covering a frequency range from 5 c.p.s. to above 200,000. The flyback is automatically blacked-out at high repetition frequencies. The synchronisation is positive. A trigger control provides means of controlling the flyback.

Terminals and controls, which are reduced to a minimum, are situated at the front of the instrument, and an innovation is the use of tandem controls affecting related circuits, which considerably simplifies operation.

Other features are (*a*) A double mu-metal shield is fitted to avoid interference from external magnetic fields; (*b*) For SB tube operation, deflector coils are fitted for direct investigation of current. A wide range is covered when using standard 75 mV shunts (C). For working at high radio frequencies, a detachable plate at the rear of the case gives access to a link panel connecting to the tube terminals; (*d*) A calibration voltage is provided from an additional winding in the mains transformer; (*e*) A slide on a transparent 10 cm. scale is supplied for quantitative determinations, the same fixing being designed to secure a film camera; and (*f*) Shift controls are provided for X and both Y plates.

The new Cossor oscillograph, Fig. 74, designated model 3379, has been designed to meet the needs of laboratories, requiring an instrument having a larger screen area than that provided by the model 3339, Fig. 73, and capable of producing a permanent record. While the 3339 oscillograph may be used with its appropriate camera for photographic purposes, the writing speed available is necessarily limited and the demand for high speed working has been borne in mind during the development of the model shown in Fig. 74. The maximum high tension voltage of 4000, while intended to give the finest focus also serves for the parallel requirement of photography. The larger instrument makes use of a trapezium corrected high vacuum 9in. diameter tube and the single and double beam types may be interchanged without any alteration to the equipment. The necessary voltages for accelerating and focusing the cathode ray tube are provided by a half-wave rectifier system, the choice of four anode voltages up to a maximum of 400 being available by switching at the front panel.

Controls are also provided for the adjustment of the brilliance and focusing potentials and for horizontal and vertical positioning of the traces. A special voltage stabilising circuit is incorporated in the astigmatism correction circuit. The time base voltage is generated by a hard valve circuit of the original Cossor type and provides return trace suppression at all speeds above 50 c.p.s. with or without simultaneous intensity modulation from an external source. Rigid synchronisation is obtained over the entire time base range of from less than 4 c.p.s. to above 200 kc.p.s., the load reflected by the synchronising circuit being sensibly constant at all settings of the control.

The amplitude adjustment produces no changes of frequency and the circuit is compensated so that no change in the X deflection amplitude occurs when the deflection sensitivity is varied as a result of the selection of different accelerating voltages for the cathode ray tube. The amplified time base voltage (balanced above earth) is available at the front panel for external use. Two separate single stage pentode amplifiers are incorporated. Each has a gain of more than 100 times and a sensibly uniform response extending below 20 c.p.s. to above 100 kc.p.s. These valves may be used separately to feed the two individual Y deflector plates of the Cossor double-beam tube or to furnish a balanced output voltage from a signal which is balanced about earth. Alternatively, they may be switched so as to provide a balanced deflection voltage from a single source, one side of which is earthed.

The response does not fall steeply above 100 kc.p.s. and the amplifiers may therefore be used with effect for many measurements at considerably higher frequencies. A separate five-position frequency compensated input attenuator producing a drop of 6 db. per step is provided for each amplifier valve, and both the input and output are available at the front panel at all switching positions, enabling the amplifiers to be used externally. Intensity modulation signals may be applied to the tube unamplified, or in addition a single stage amplifier having a useful frequency response extending to above 2½ Mc.p.s. may be connected in circuit when such modulation is required from signals of small amplitude. A continuously variable gain control down to an amplification of about twice is provided on this stage in such a way that the response of the amplifier does not change materially irrespective of its setting.

The equipment is entirely self-contained and is designed for operation from a 40–100 c.p.s. supply of 110 volts or 200 volts, and with the exception of the mains fuse and supply voltage selector all the controls and terminals are mounted on the front of the panel. A detachable plate is, however, provided at the rear of the case to give access to the fuse and selector and to a set of links in the grid and deflector plate circuits of the tube. Removal of these links enables the tube to be directly connected to external circuits without the loading of the internal circuits of the oscillograph which is of great value for measurements of very high frequencies. A camera is obtainable to fit in the guides fixed on the front panel.

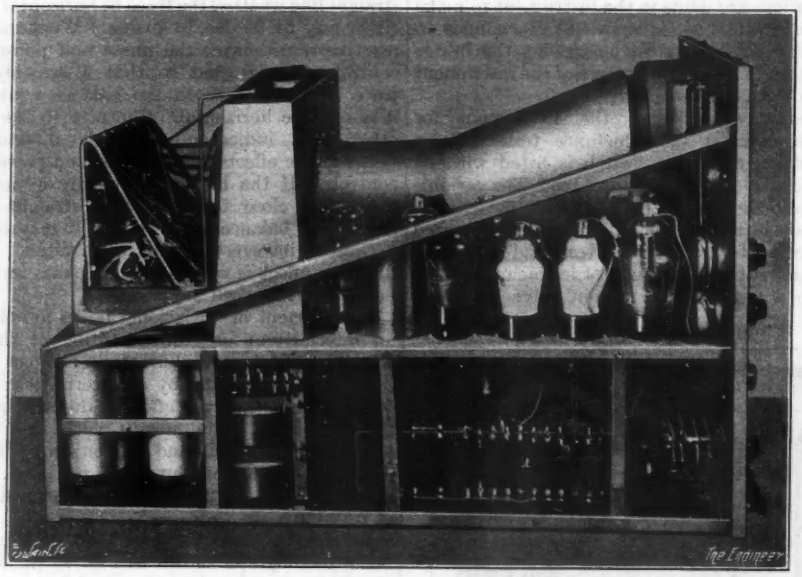


FIG. 74—MODEL 3379 OSCILLOGRAPH

(To be continued)

Railcars for the Great Western Railway

No. I

As noted in our annual review article on January 12th, production of railcars Nos. 19 to 38, forming an order for 20 cars for the Great Western Railway, was in progress during the winter months at the works of the Associated Equipment Company, Ltd., at Southall. Despite current manufacturing difficulties, the company has been making steady deliveries of chassis to Swindon for the fitting of bodies. The new vehicles are generally similar to the last of the 18 railcars previously delivered to the G.W.R.—a vehicle designed for hauling tail loads and differing in many respects from its forerunners.

Following upon the experience gained in operating that unit, the cars forming the new order are modified in many respects and have several novel design features. A new control system has been evolved whereby multiple-unit working by means of electro-pneumatic gear, controlled from either end of a single car, a twin-car, or a larger rake, is achieved. By increasing the bogie wheelbase smoother running has been obtained. At recent chassis trials, at which we were present, the effect of this modification was clearly noticed. A novel feature of certain of the vehicles is that in addition to the standard Wilson epicyclic gear-box, arranged to give five ratios, a dual-ratio auxiliary gear-box is incorporated. This arrangement enables the vehicles either to be operated within a high range of gears when used for fast service solo, or coupled with another power vehicle, or to be operated on the low range of gear ratios when used for hauling tail loads. By this means also the need for the manufacture and fitting of alternative gearing

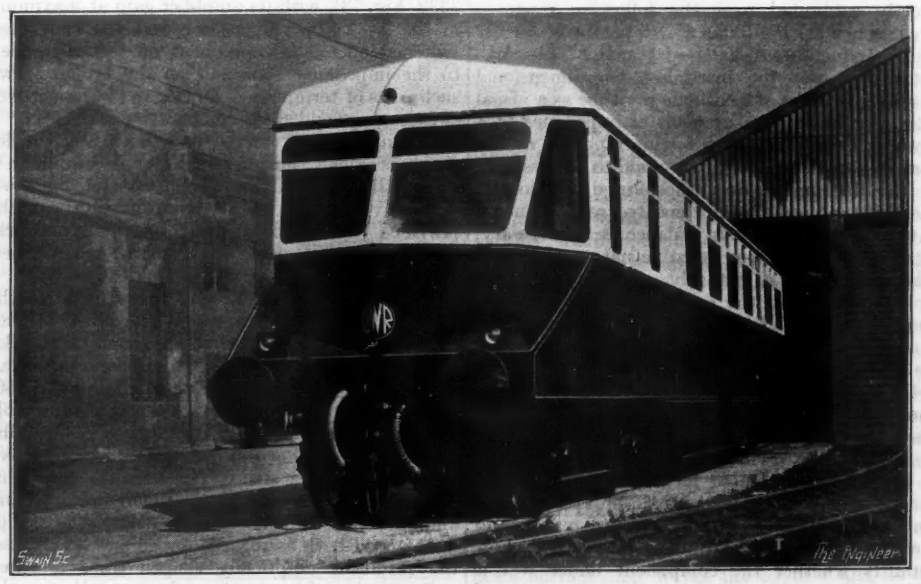


FIG. 1—COMPLETED RAILCAR NO. 19

in the final reduction gear-boxes is eliminated.

Of the 20 new vehicles, four are to be arranged as twin-coupled units with vestibule connections (Fig. 2) and are to be provided with gear ratios suitable for a maximum speed in excess of 70 m.p.h. One car is to have a body designed for parcels carrying, and the remaining 15, designed for lower speeds and greater tractive effort, are to be used for local services. The top-gear ratio of the twin-coupled cars is designed to give a maximum speed of 75½ m.p.h. On the single-unit cars the speed is 42½ m.p.h., and on two cars, which are to be fitted experimentally with dual-range gear-boxes, the maximum designed speed is 63·7 m.p.h. on high gear and 42·5 m.p.h. on low gear. The single-unit vehicles are designed, we are informed, for hauling tail loads of up to 60 tons. Accommodation is provided for 48 passengers in the case of the single units, and for 104 passengers in the case of the twin-coupled sets.

We reproduce in Fig. 1 a view of the first of the new vehicles—No. 19, a single-car unit—to be completed, and in Fig. 4 a view of the chassis of this car. As may be noted in the engravings, the general layout is similar to that of previous vehicles made by this firm. Twin-engines, each having six cylinders and an output of 114 B.H.P. at 1650 r.p.m., are arranged one on each side of the main frames. The engines are of the direct-injection type, fitted with toroidal heads, giving an increased power, and are provided with an oil-cooling system using water-cooled grids in the main sump, arranged so as to be easily removable for cleaning. The engine mounting and cooling system has been modified, so that the engines no longer are placed centrally on the frames, but are staggered. As shown in Fig. 5, the engine cooling system comprises a new arrangement of the radiator and fans, the radiator being placed between the engine and gear-boxes. Transmission of power to the gear-boxes is effected by a countershaft and two carden shafts mounted in line. The fixed counter-shaft is mounted behind the radiator and in addition to carrying a fan on each end, is fitted with pulleys for driving vacuum exhausters and dynamo. A short carden shaft connects the front end of this counter-shaft to the engine, and a longer one connects the rear

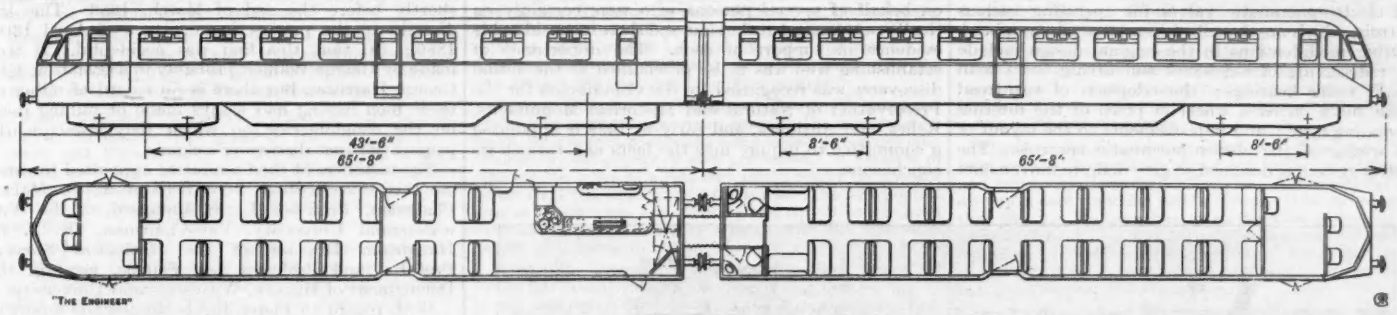


FIG. 2—ARRANGEMENT OF TWIN-COUPLED RAILCARS

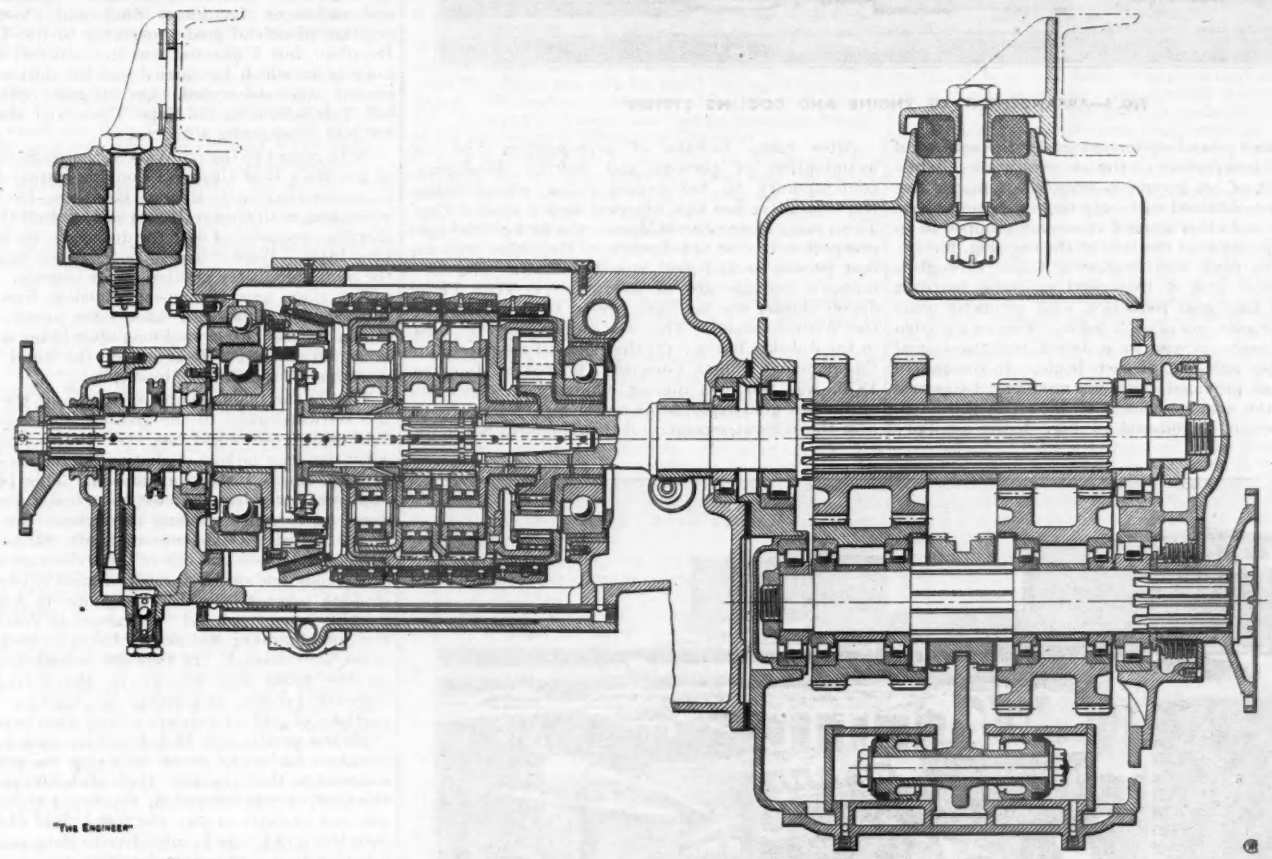


FIG. 3—LONGITUDINAL SECTION THROUGH FIVE-SPEED EPICYCLIC AND TWO-SPEED AUXILIARY GEAR-BOXES

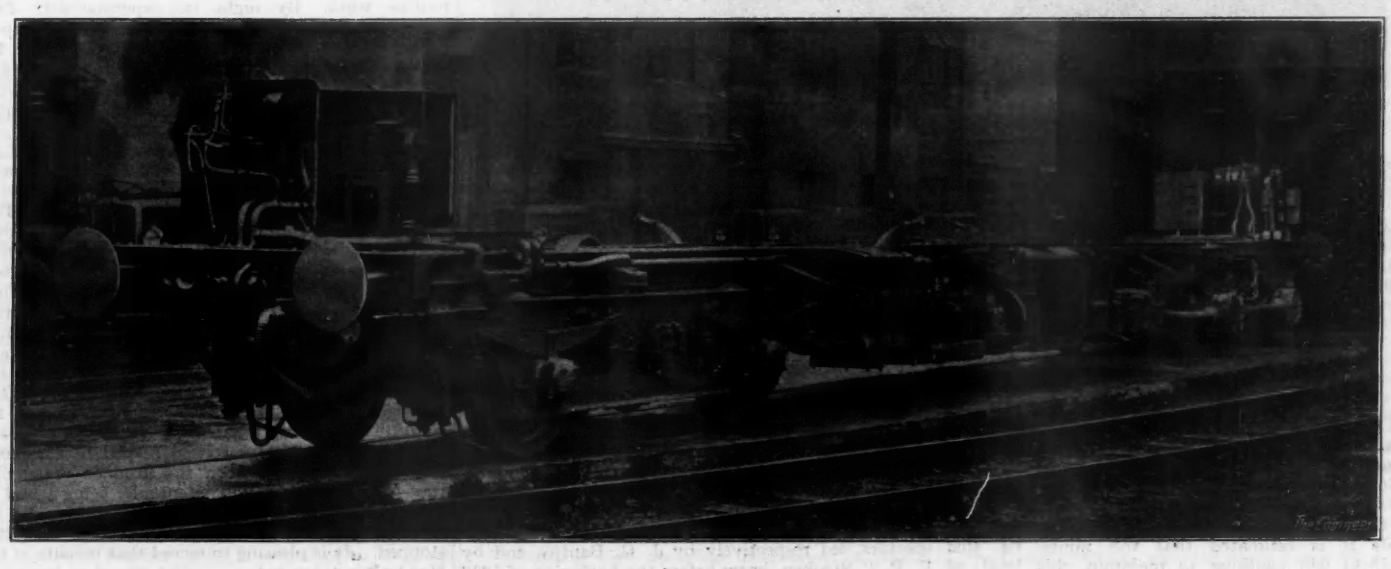


FIG 4—CHASSIS OF RAILCAR NO. 19

end to the gear-box. It is claimed that this new design enables the radiator to occupy a smaller space, to be readily accessible and to produce efficient cooling independently of the direction of motion of the vehicle. The arrangement is perhaps more clearly seen in Fig. 6, which also shows part of a gear-box and electro-pneumatic valves for operating various controls, which are described in a later paragraph.

Other modifications to the original design include the redesigning of axleboxes and fitting them with S.K.F. roller bearings; the adoption of two-tread brake shoes on each wheel in place of the internal expanding type; and improvements to the layout of the wiring of the electro-pneumatic controls. The control system is designed to give definite movements

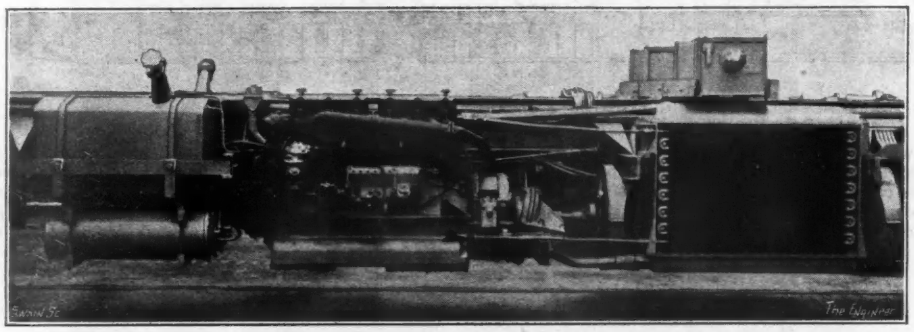


FIG. 5—ARRANGEMENT OF ENGINE AND COOLING SYSTEM

for all motive power equipment under the control of the driver, irrespective of the air pressure available By the use of an ingenious preselector motor five positions are obtained with only three magnet valves. Both these and other control valves are grouped in an accessible position at the side of the car (Fig. 6).

The drive from each engine is taken through a fluid flywheel and a five-speed epicyclic gear-box to a bevel final gear reduction with reversing gears in the inner axle-box of each bogie. Thence a carden shaft transmits power to a bevel reduction gear on the outer axle-box of each bogie. In the case of the vehicles provided with an auxiliary two-speed gear-box, the arrangement is as shown in the longitudinal section reproduced in Fig. 3, the auxiliary

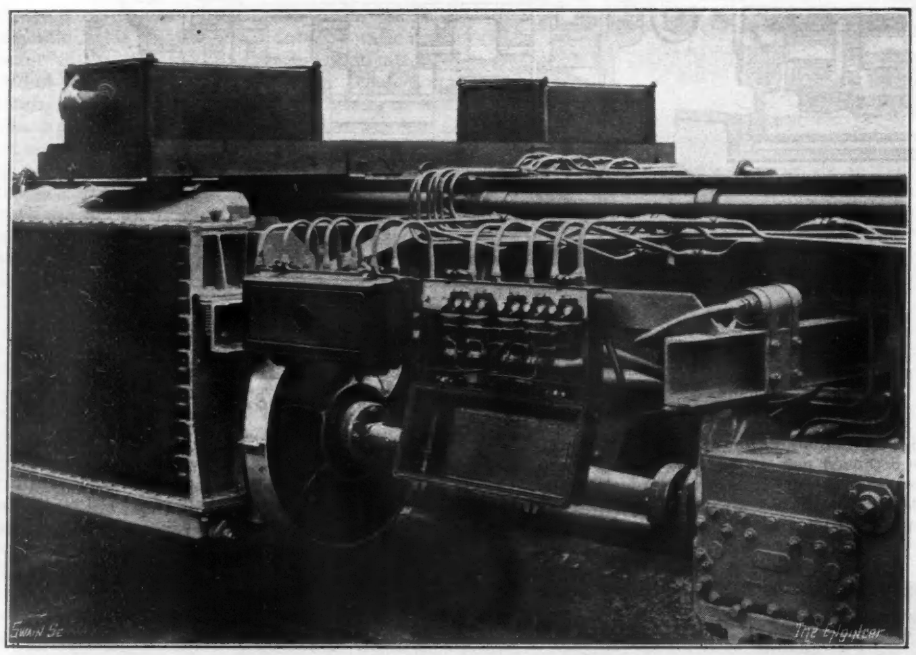


FIG 6—RADIATOR, CONTROL VALVES AND GEAR BOX

gear-box being mounted directly on the output end of the epicyclic gear-box. The main gear-box ratios range from direct drive to 6·38 to 1; the auxiliary gear-box reductions are 0·919 to 1 for the twin-coupled units and 1·63 to 1 for the single units; and the final drive reduction in the axle-boxes is 2·59 to 1.

(To be continued)

The Witwatersrand Goldfield

(By our South African Correspondent)

THE richest goldfield recorded in the history of mining—the Witwatersrand—was discovered in the Transvaal Province of the Union of South Africa in 1886. In the year 1889 gold to the amount of £81,045 was recovered and the value of the output for the present year will certainly exceed £95,000,000, while it is estimated that the mines on this goldfield will continue to maintain this level of production for at least 30 years and probably more.

Now that the Witwatersrand has passed its fiftieth birthday and has become so famous, there has been much discussion as to who was the actual discoverer of the "Rand" goldfield, and particularly of the "Main Reef." Claims have been advanced on behalf of several persons who were certainly on the Witwatersrand at the time and there is considerable evidence in support of each. The importance of establishing who was to be proclaimed as the actual discoverer was recognised by the Commission for the Preservation of Natural and Historical Monuments, Relics, and Antiques, and early in 1939 it appointed a committee to inquire into the facts and furnish its conclusions.

After many months of investigation and the examination of persons and written documents, contemporary to the period under consideration, the committee has now reported that it finds a Cape Town man, Pieter Jacob Marais, the first official gold prospector to the old Transvaal Republic, was the first person to find gold near the Rand. The committee's findings are as follows:—(1) That Pieter Jacob Marais was the first person to find gold near the Witwatersrand. This was on October 8th, 1853, in the Jukskei River; (2) that the Nil Desperandum Co-operative Quartz Company, floated in January, 1875, was the first mining company to carry out systematic gold exploitation on the farm Blaenwbank, near the Witwatersrand; (3) that the farm Kromdrai (about 10 miles north of Krugersdorp) which had been prospected since 1881, and was proclaimed a public diggings on December 8th, 1885, was the first farm to be officially proclaimed a goldfield in this area; (4) that the battery erected on Tweefontein during the winter of 1885 by the Hammerschlag Company was the first gold quartz crushing machinery to be erected near the Witwatersrand and that this produced the first gold, in any appreciable quantity, from this area; (5) that the two brothers H. W. and F. P. T. Struben, by their extensive and persistent prospecting and mining activities on the Witwatersrand, both north and south of the Main Reef Group of Conglomerates from 1884 to early in 1886, attracted so much attention to this area that the subsequent discovery of the Main Reef Group Conglomerates became inevitable. The Strubens made the greatest individual contribution to the discovery of the Witwatersrand goldfields; (6) that two sets of prospectors, led respectively by J. G. Bantjes and by F. P. T. Struben, knew before the beginning of 1886 that conglomerates of the Witwatersrand were auriferous, and excavated, panned, and milled conglomerates from the lower part of the system and later from the Bird Reef; (7) that the Main Reef Group of conglomerates was first found on G. C. Oosthuizen's part (Portion C of the farm Langlaagte) shortly before the end of March, 1886. This led directly to the prospecting contract of April 12th, 1886; (8) that this find was accidental. It was made by George Walker, probably in association with George Harrison, but there is no record of either of these men having had assays made or milling done on the conglomerate on which they subsequently pegged contract discoverer's claims.

The members of the Committee appointed to carry ou this investigation were Senator F. S. Malan, Chairman, Professor L. F. Maingard, of the Witwatersrand University, Vice-Chairman, Dr. S. H. Haughton, Director of the Geological Survey, Pretoria, and Professor Leo Fouche, head of the Department of History, Witwatersrand University.

With regard to Pieter Jacob Marais, the report of the Committee states that, born and bred at Cape Town, he developed the "wanderlust" and sailed to San Francisco and there joined the gold rush of 1849, and had some success. Leaving California, Marais went to Australia in 1851, and at the Bendigo diggings and elsewhere he had some fortune. In 1853, he left Melbourne to return to South Africa. On September 3rd, 1853, he reached Potchefstroom and called on Landdrost Smit and obtained the position of official gold prospector to the Transvaal Republic, but Volksrand was not satisfied as to the manner in which he carried out his duties and the permit was suspended. On August 30th Marais left Potchefstroom for Cape Town and thus ended his gold prospecting activities.

With regard to George Walker, the accidental finder of the Main Reef Group of Conglomerates—probably in association with George Harrison—he was also associated with George Honeyball, and all three were therefore acquainted with the discovery but benefitted very little. Walker was in poor circumstances until the mining industry granted him a pension. He died a few years ago. Harrison vanished from ken in Barberton and has not since been heard of, while Honeyball was discovered long after living in poverty in a mud cottage. He is now on the Rand, also as a pensioner of the Gold Industry.

This is the plain unvarnished tale of the start on the Witwatersrand of the greatest and richest goldfield which the world has ever known, and whose activities show no sign of abating but, on the contrary, promise much further expansion. This plain tale, however, could be expanded to reveal a great abundance of romance running throughout the 53 years of the industry's existence in South Africa. It has had several crises and one of them deserves mention.

Without one chemico-metallurgical invention, the cyanide process, the Rand Goldfields might very possibly have "petered" out about 40 years ago and the Johannesburg and South Africa of to-day would never have existed. In 1889–90, indeed, the position on the fields was gloomy in the extreme. The mercury process, depending on catching the fine particles of gold on mercury plates, was the one in use. With the pyritic ores then being encountered, as the workings had to go lower, following the gold, it was wasteful in the extreme. Only about 60 per cent. of the gold, it was estimated, was being recovered. It was not enough to pay the cost. But chemists all over the world were keenly alive to the possibilities of a better process of gold extraction.

In Glasgow a young Scottish chemist had found something better, and John Stewart MacArthur by the researches he had carried out a year or two earlier, was to become the saviour of the industry. MacArthur at that time was employed in a junior capacity as a chemical metallurgist by the Tharsis Sulphur and Copper Company, a Glasgow firm with interests in Spain. By day he was engaged on routine work. By night he experimented. Two Glasgow doctors—R. W. and W. Forrest—placed their cellar at his disposal. There he worked away at his problem. A solution of a gold salt used in toning photographic prints suggested a method of dissolving the precious metal. He passed a weak solution of sodium cyanide over his ore. The problem of dissolving the metal was solved. It remained to find a way of re-precipitating it. MacArthur achieved it by passing the solution of the double salt of sodium and gold cyanide over zinc filings. This method is still considered the best. There is some uncertainty as to whether the process was tried first in New Zealand or South Africa, but the crucial test took place in this country at the old Salisbury Mine, in the first half of 1890. MacArthur himself carried it out, under strict supervision, for Johannesburg was wise to the methods of "salting" a claim, and was quite aware that "salting a process" was not difficult. The result was a triumphant success. The experiment showed a recovery of 98 per cent. of the gold. The industry was saved. But the company with which MacArthur worked reaped little benefit. Objections were raised on the grounds apparently that the process was not patentable, being based on known reactions. The Transvaal courts upheld the companies and those who had begun to pay royalties stopped. It is pleasing to record that in spite of this MacArthur prospered.

Rail and Road

ANOTHER LONG ROAD BRIDGE IN AMERICA.—Construction is expected to begin shortly of a road bridge about 7½ miles long across Tampa Bay in Florida between Tampa, St. Petersburg and Clearwater.

NEW RAILWAY IN GREECE.—A new railway line has been opened in Greece between Myrrine Amphipolis and Tsagesi. Built at a cost of about £140,000 it connects Salonika with the centre of Eastern Macedonia.

FRENCH RAILWAY ACCIDENT.—When the express from Paris to Montlucon was derailed between Epineuil-le Fieuriel and Vallon, early on the morning of Sunday, May 5th, more than 20 persons were killed and a number seriously injured. It is stated that the accident was caused by the sudden collapse of a bridge weakened by heavy rains.

RAILWAY PURCHASE BY MEXICAN GOVERNMENT.—The Mexican Government is to purchase the Kansas City, Mexico and Orient Railway from the Atchison, Topeka and Santa Fé Railway. This line is 330 miles long and it is proposed to make extensions over the Rio Grande River and from El Paso, in Texas, to Topolobampo, on the Gulf of California.

USE OF ABANDONED TRAMWAY TRACK MATERIAL.—At the conference of the Public Service Transport Association it was suggested by Sir Joseph Nall that the owners of tramway track, particularly points and crossings, which were about to be scrapped but were still in a usable condition, might with mutual benefit offer them to authorities which needed them for track repair purposes, so saving the time and expense involved in turning them into re-made steel.

TURKISH RAILWAY CONSTRUCTION.—According to a report of *The Times* correspondent in Istanbul plans for the extension of the Turkish railway system to Iran and Iraq, for which the Kamutay granted a credit of about £10,000,000 have been somewhat modified. The line from Diarbekir and Bitlis to Van will be constructed with a ferry-boat service across Lake Van; but the line from Diarbekir to Iraq has been abandoned, and communications with Iraq will be confined to the Nuseibin–Baghdad line.

L.P.T.B. STAFF CHANGES.—As a result of the retirement of Mr. Frank Pick from the London Passenger Transport Board, a number of changes have been made in the organisation. Mr. V. A. M. Robertson, at present Chief Engineer (Civil), will be the Engineer-in-Chief and his department will comprise the whole of the engineering departments of the Board—civil, mechanical and electrical. Mr. H. J. Green succeeds Mr. Robertson as Chief Engineer (Civil), and Mr. F. C. Bentley is to be Assistant to the Engineer-in-Chief.

INCREASES IN LONDON TRANSPORT FARES.—The Railway Executive Committee proposes further increases of fares and adjustment of stages on London Passenger Transport Board Services. These increases will be considered at a public inquiry on May 22nd by the consultative committee of the Railway Rates Tribunal. It is proposed that 1d. fares should be increased by ½d. and minimum workman's fares of 2d. to 3d. Shorter stages for distances at present costing up to 6d. and an increase of 10 per cent. for fares of 7d. or over are among other proposals.

LOCOMOTIVE BUILDING COSTS IN INDIA.—Some little time ago Messrs. J. Humphries and K. C. Srinivasan were appointed to inquire into the feasibility and cost of the building of locomotives in India. In their report they estimated that the total cost of production of an "XE" broad gauge locomotive, complete with boiler and tender, at Kancharapara, the workshop chosen to be converted for the purpose, would be Rs. 98,000, which would be about 20 per cent. cheaper than imported locomotives. The cost of conversion of the Kancharapara workshop is estimated at Rs. 47½ lakhs.

THE YUNNAN–BURMA RAILWAY.—According to reports received by the *Far Eastern Review*, work is still proceeding on the construction of the Yunnan–Burma Railway. Lack of labour and materials has made it necessary to concentrate upon the completion of the eastern section of the line instead of beginning work at a number of points as was at first contemplated. A considerable amount of the labour which would otherwise be used for the railway is engaged in making the Yunnan–Burma highway into an all-weather road so that traffic will not be interrupted by landslides and wash-outs during the rainy season.

GAS-DRIVEN VEHICLES IN LONDON.—At a conference of the London Gas Development Association it was stated that the use of gas for transport purposes is practicable throughout the whole of Greater London. A network of supply points has been set up at more than eighty different stations in the Metropolis, where owners of commercial vehicles and private cars can fill up with gas which is not rationed. It was pointed out that sufficient gas can be carried in bags on private cars to cover from twelve to twenty miles without refilling, and lorries up to twenty miles or more. Refilling can be done in from seven to ten minutes. The cost of conversion at present varies from £30 for an 8 horsepower car to £48 for a 3-ton lorry.

PURCHASE OF THE BENGAL–DOOARS RAILWAY.—Reports in the Indian press state that the Secretary of State, acting on the recommendation of the Government of India, has given notice of purchase of the Bengal–Dooars Railway. The payment of the purchase price will be made in England in 1941–42. The railway is a metre gauge line about 160 miles in length owned by the Bengal–Dooars Railway Company which works it under contracts with the Secretary of State. The Secretary of State has the right to purchase the line on December 31st, 1940, by giving the company twelve months' previous notice. The purchase price of the original line, 39½ miles, is fixed under the contracts at 140 per cent. of the capital expenditure, and of the extensions, 121 miles, at 25 times the average net earnings subject to a minimum of 100 per cent. and a maximum of 120 of the capital expenditure. On this basis the purchase price is estimated to be about £1,284,000 or Rs. 171 lakhs.

Miscellanea

NEW POWER STATION AT KINGSTON.—It was stated at a recent meeting of the Board set up in connection with the Hogsmill Valley drainage scheme that the present site of the Kingston Sewage Works and the adjoining power station would probably be required for a new selected power station to be built under the South-East England Electricity Scheme. It is expected that the new station will cost about a million pounds.

EASILY REMOVABLE WELDING TORCH NOZZLES.—A useful hint is given in a recent issue of *The Machinist* by which the removal of welding torch nozzle tips is not only facilitated but leakage is also prevented. It consists of drawing the point of a soft lead pencil round the threads before the tip is screwed into the torch. The lead deposit acts as a lubricant and permits the tip to be removed without the use of a heavy wrench with the attendant danger of cracking the head.

MORE OIL PROSPECTING LICENCES.—The Board of Trade has issued three more prospecting licences for oil in this country to the D'Arcy Exploration Company, Ltd. These licences cover an area of about 179 square miles in the counties of Lancaster, Chester and Flint, including part of the River Mersey; an adjoining area of about 156 square miles in the counties of Chester, Flint and Denbigh, including the estuary of the River Dee; and an area of about 197 square miles in Leicester, Nottingham and Rutland.

DEATH OF MR. F. G. MOLLOY.—Many of our readers both in this country and abroad will learn with regret of the sudden death on Tuesday, May 14th, following a short illness, of Mr. F. G. Molloy, who was in the London office of Babcock and Wilcox, Ltd., and had charge of sales in British Dominions and Possessions. For many years Mr. Molloy was with the allied Babcock Company in Japan. He graduated with the B.Sc. (Eng.) Degree in the University of London and was an Associate Member of the Institution of Mechanical Engineers.

HIGH OCTANE FUEL PRODUCTION IN AMERICA.—It is stated in the American press that more than 200 million dollars have been spent in developing the large scale production of 100-octane fuel in the United States. It is expected that the refineries in that country will soon be in a position to produce 100-octane fuel at the rate of 40 million tons a month. The selective refining processes adopted utilise either phosphoric or hot sulphuric acid. It is thought that, apart from its use in aeroplane engines, a further field of application of this fuel will ultimately be found in road transport.

TELLURIUM IN TIN ALLOYS.—It was shown by Dr. Hanson and Dr. Pell-Walpole some time ago that a little tellurium improves the creep strength of pure tin, both in the rolled and the cast conditions. A convenient method of determining tellurium in these alloys has been worked out by Dr. Pell-Walpole. He ascertains the loss of weight that occurs on distillation *in vacuo* when tin telluride (Te Sn) distils without dissociation. A note of the method forms Publication 96 of the International Tin Research and Development Council, Fraser Road, Greenford, Middlesex, England.

WARMING BAKELITE FOR PUNCHING.—An American company experienced trouble in the blistering of bakelite when it was warmed, preparatory to punching, in a 1000 watt strip oven. This blistering was believed to have been caused by the raising of the surface temperature of the Bakelite too high in an attempt to secure heat penetration right through the strips. The heating oven was replaced by a bench over which was suspended a number of infra-red lamps. The bakelite was laid on the bench and it was found that the radiant heat from the lamps thoroughly penetrated the strips and eliminated the formation of the blisters.

THE INSTITUTION OF MINING AND METALLURGY.—The Gold Medal of the Institution of Mining and Metallurgy, the highest distinction in its power to bestow, has been awarded to Mr. S. G. Blaylock, "in recognition of his outstanding achievements in advancing the science of metallurgy in the Dominion of Canada." The "Consolidated Goldfields of South Africa, Ltd." premium of forty guineas has been awarded to Mr. A. C. Skerl for his paper on "The Geology of the I.X.L. Gold Mine, Masbate Island, Philippines." The "William Frecheville" Students' Prize of ten guineas has been awarded to Mr. G. A. Schnellmann and the "Arthur Claudet" Students' Prize of ten guineas to Mr. Ralph Daniel.

ZINC MELTING.—At the aircraft works of the Glenn L. Martin Company in the United States an improved system of melting zinc for die casting work has been introduced to avoid the wastage caused when melting the metal in pots set directly over a flame. This method was found to be not only wasteful in that the zinc alloyed with the hot metal at points where the heat was concentrated, but the melted product frequently absorbed impurities owing to contact with the pot metal where heat was most intense. The new design of melting equipment consists of a large pot protected outside by a refractory material and set over a combustion chamber. In it lead is kept in the molten state and into this lead smaller pots containing the zinc are partly immersed. The even distribution of the heat round the zinc melting pots avoids the detrimental effects of direct heat applied unevenly at points on the outside surface.

AN UNCONVENTIONAL POWER STATION.—What is thought to be the forerunner of an entirely new trend in power station design is to be constructed in the United States at Glendale in California. The new plant will cost considerably less than the conventional type of station as heavy building structures are being dispensed with entirely. The boilers are being enclosed with a stucco covered light steel frame housing and a hydrogen cooled turbo generator unit is to be erected on an open deck served by a travelling crane. According to the *General Electric Review* there is no reason why turbine generators cannot be installed outdoors in any part of the country. Hydrogen cooling makes the outdoor installation of turbine generators a practicability; such machines are completely self-contained, and are hydrogen-tight and air-tight, making their operation independent of weather conditions and changes.

Air and Water

ADMIRALTY APPOINTMENT.—An Admiralty announcement states that Rear Admiral H. R. Moore has been appointed a Lord Commissioner of the Admiralty and Assistant Chief of Naval Staff in succession to Rear Admiral H. N. Burrough.

SHIPYARD IMPROVEMENT IN U.S.S.R.—For the purposes of reconstructing the Marty shipyards in Odessa to make them suitable for the construction of sea going vessels, the U.S.S.R. Commissariat of Marine Transport has allocated a sum of 76 million roubles.

RESUMED AIR SERVICES IN BRITAIN.—Air services have been resumed between Liverpool and Belfast and Glasgow and Belfast by Railway Air Services. Each weekday one service in each direction will be flown. It is also reported that the Air Ministry has given permission for the re-commencement of a number of the Scottish air services including the Hebrides route via Tiree, Barra, Benbecula and North Uist from Glasgow and a new direct route between Glasgow and Stornoway.

AIR SERVICES IN JAPAN.—The Japanese Airways Company has ordered a fleet of twin engined air liners capable of carrying eleven passengers and a crew of four at a speed of over 180 m.p.h. Some of these machines will be used on a service to be inaugurated between Japan and Thailand (Siam), and others on routes between Japan, Manchukuo and China. When the new machines are in service it is expected to reduce the time taken between Peiping and Tokyo to eight hours.

TRAWLER WHEELHOUSE PROTECTION.—A method recently introduced of protecting the wheelhouses of trawlers and small vessels against the effects of machine gunning consists of building a box of standard concrete paving slabs around them. The slabs used are of a minimum thickness of 2½in., and are well able to withstand ordinary bullets. This form of protection is not only lighter and less cumbersome than sandbags, but has the advantage that it is easily erected on a framework and does not deteriorate under any weather conditions.

A NEW GERMAN PROTECTIVE PAINT.—An Air Ministry abstract from a French journal describes a new German protective paint known as "Sigal." It is a rust-inhibiting pigment based on the corrosion-resistant properties of Al-Si alloy. It consists essentially of the eutectic alloy 87 per cent. Al, 13 per cent. Si, with the addition of elementary Si. The whole is ground to a fine powder in a ball mill with air separation, so that no residue is left on a sieve of 16,000 mesh/square cm. The film is very elastic, the elasticity increasing with increasing substitution of resinous material for linseed oil. Sigal priming coats are made up without addition of oil, while finishing coats contain up to 5·8 per cent. linseed only.

SHIPBUILDING IN CANADA.—The ship construction programme in Canada is reported to be proceeding well ahead of schedule. At fifteen shipyards along the coasts and inland waters work continues day and night. The present two-year programme calls for the construction of over 100 vessels for various naval and air force purposes, including 64 patrol ships and 26 minesweepers. The construction of some of these larger ships is far advanced. They will be delivered this year and others in 1941. The vessels on which work is now under way are required for the defence of coastal waters, for general service with the Royal Canadian Navy, for the Royal Navy, and as service boats for the Royal Canadian Air Force.

SHIPPING LOSSES.—During the week ended Sunday, April 28th, four British ships totalling 6689 tons, one allied ship of 1458 tons and two neutral ships of 298 tons were sunk by enemy action. Since the war began 22,555 ships have been convoyed, and of these only 38 have been lost. German mercantile tonnage definitely accounted for as captured, sunk or scuttled now amounts to 454,000 tons. In addition, it is estimated that a further 30 unidentified ships of approximately 150,000 tons have been sunk by allied submarines, mines or aircraft. The total German loss of merchant tonnage, including transports and supply ships, must be over 600,000 gross tons, of which about one half, or 300,000 tons, has been lost since April 1st.

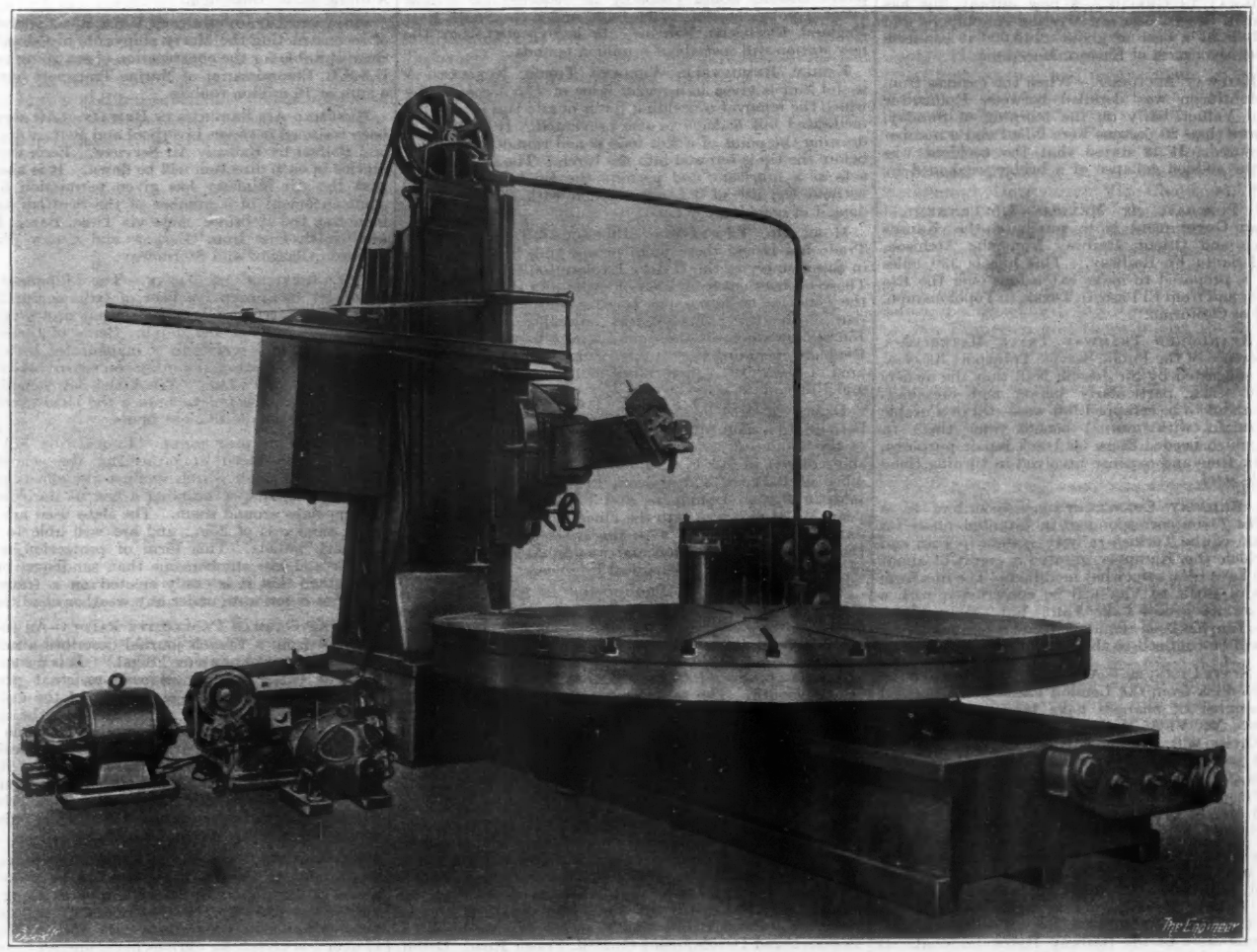
THE YELLOW RIVER.—According to reports received by the *Far Eastern Engineer*, the future of Shanghai as a trading port is threatened as a result of an attempt by the Yellow River to change its course. It is stated that mud and silt now passing into the Yangtse River, via the Hwai River, will eventually bring about its overflowing and the flooding of the lower Yangtse valley and will cause this and the Yellow River to change their courses. When the Yellow River broke its dykes in 1938 near Kaifang its waters poured into the Hwai River and via the Hungtseh Lake and the Grand Canal into the Yangtse River. It was hoped this year that the waters of the Yellow River would flow into the old channel, but it is now found that its main stream is flowing into the Hwai River destroying the dykes and entering the Yangtse River. Chinese authorities had planned to build a series of dykes to force the Yellow River back into its old channel, but the war still in progress in Honan has prevented the carrying out of these works and the waters are now passing through the lower Yangtse Valley.

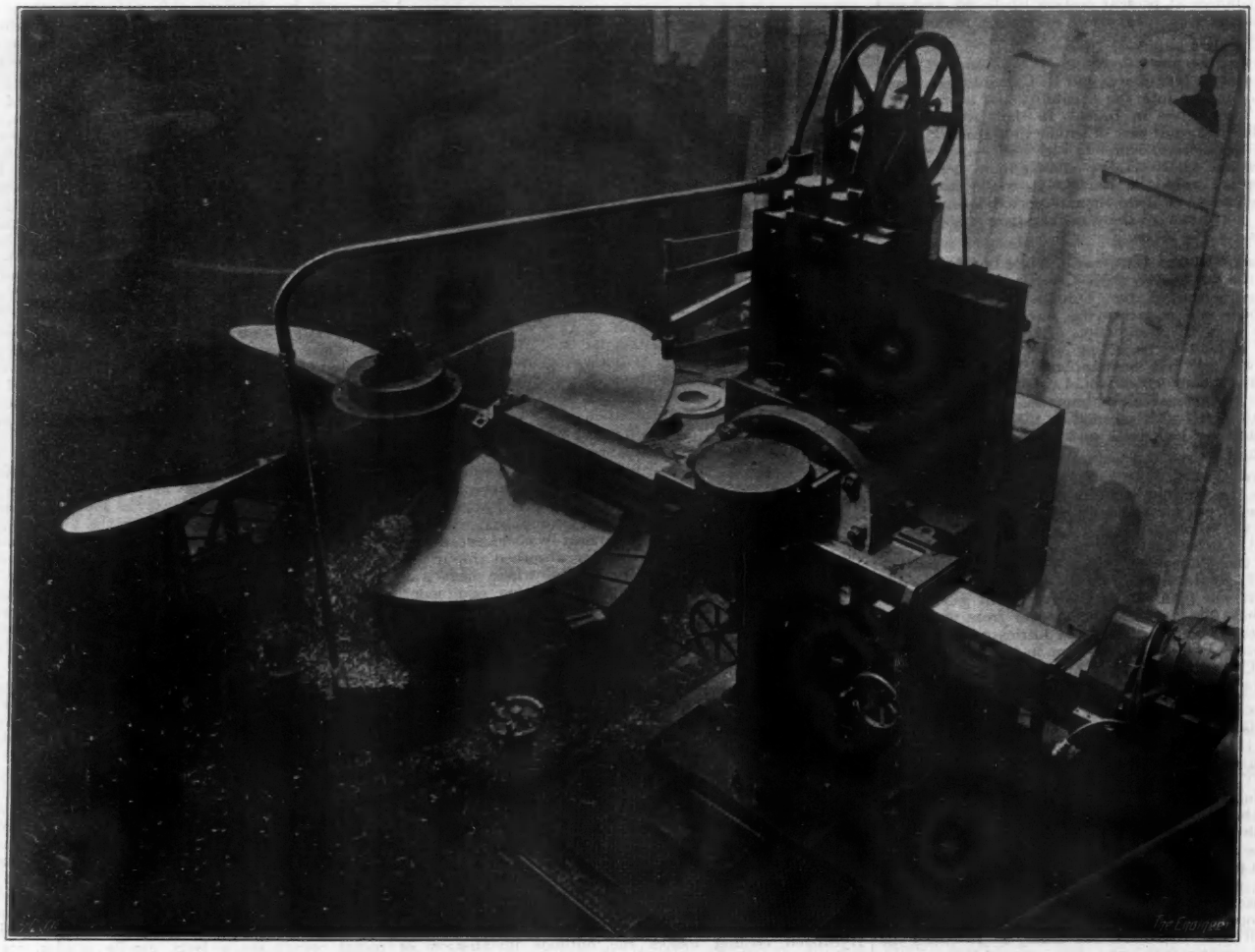
EXTINGUISHING INCENDIARY BOMBS.—A new form of equipment for extinguishing incendiary bombs has been developed by the Nuswift Engineering Company, Ltd., of Elland. It is particularly difficult to extinguish thermite bombs as the oxygen for the combustion of the thermite, which lasts about 90 seconds, is obtained direct from the iron oxide and not from the atmosphere. The new principle consists essentially in the use of a mixture of inorganic salts which are brought into effective contact with the incandescent bomb and become molten, extinguishing the main burning of the electron metal bomb casing by choking the crevices and smothering the combustion, as well as reducing the temperature by cooling to below the ignition point. One of the methods of application is called the "bomb-snuffer," consisting of a metal cover, like a large candle snuffer, containing a charge of powder in a paper carton with a celluloid seal, which is placed bodily over the top of the bomb. This is particularly suitable when the bomb is on a flat surface or otherwise easily accessible.

MACHINE FOR PLANING MARINE PROPELLERS

MORTON MANUFACTURING COMPANY, MICHIGAN, ENGINEERS

(*For description see page 462*)





GENERAL VIEW OF MACHINE

MACHINE ARRANGED FOR RADIAL PLANING

The Engineer

MAY 17, 1940

VOL. CLXIX No. 4401

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THE WAR AND THE ENGINEER

WHILST none can escape the anxiety which accompanies a life and death struggle, the majority of people in this country are relieved by the ending of the long months of waiting, and moved by a hope that a decisive victory may be won in a few months instead of years. Another long drawn out war was more dreaded than a short one, however terrible it might be. We know full well what lies before us. Months of suffering and days and weeks of the bitterest anxiety. We shall meet reverses that will try our resolution no less than our courage. Tears will be the lot of many. But we shall remain steadfast to the end and we are confident that that end will be victory. Let it be always remembered that we know more of the sufferings, anxieties and disasters of our friends and Allies than we do of those of the enemy. A war in which great nations are embattled is not one-sided. Both must suffer and that which can endure longest wins in the end. It has been said of the British people that they lose every battle but the last. That may happen again. As in 1918 when the hammer-blow of the Germans seemed on the point of bringing victory to their arms, Foch led the allies to a counter-attack which in a few weeks effected the complete overthrow of the enemy. Let us all bear that in mind even if the Allies are unable to stay the advance of a force which spares nothing in human life, in treasure, or material in seeking a quick decision.

The part that engineers have played since the war began, and for many months before it, is known to all who are in touch with their industry. There has been very proper reticence about much of the work that is being undertaken and the value of that work will only be revealed as the great battle which has now opened proceeds. But apart from new developments the mass of the work that has to be done is of a humdrum nature. Millions of shot and shell and bombs; hundreds of thousands of guns; thousands of tanks, and cars and aeroplanes have to be turned out in a constant flow. They are all alike; all made to certain standards. Day in day out, night in night out, month after month, workers have to do the same things, inspectors have to check them, and managers see that there is no delay in output and that the organisation works smoothly. Whilst nothing happened, whilst the war was stagnant, a fog of boredom had to be fought, as much in the workshop as in the trenches. The events of the past week have dissipated it. Every person, from the highest to the lowest, in every armament factory in the land, knows now that what he or she is making is needed, and is needed at once. Boredom will be replaced by excitement, the excitement of a race in which we have to catch up with an enemy who had a long start, before he can reach his goal. We are confident that the effort made in the engineering factories of Great Britain and the Empire will meet the call. We are, probably, on the last lap. A great spurt is called for and we are competent to make it. Our faith in our engineers of all classes was never more profound than it is now; it but needed a stimulus to call forth the best that is in them. That stimulus has been given. We know that the response to it will be magnificent and the end victory.

Troops by Air

IT is impossible not to be impressed by the way effective use has been made by the German Air Force of the ability to transport troops with exceeding rapidity by air. Indeed any success that the invaders may have had in Norway was in no small measure due to the acceleration in action which the use of this form of transport made possible. In itself the construction of special aircraft for the carriage of troops is not new, indeed the requirement differs but little from those of the large type of civil aircraft. Its possibilities were first brought home in dramatic fashion to the British public twelve years ago when some hundreds of civilians, largely women and children, were hurriedly evacuated—across exceedingly difficult Afghan country—from Kabul to India—without a single casualty. To carry troops on a really impressive scale requires, however, the employment of considerable numbers of aeroplanes, since the usual load on a single flight is but 25 men plus their light equipment. In the present war, however, the numbers of aeroplanes available are adequate to almost any task, even this, and if what has been published lately is correct, the German Air Force conveyed several tens of thousands of troops to Norway besides providing them with machine-guns, and possibly light field guns as well. The carriage of quite heavy machinery by air, provided it can be sectionalised, was seen many years ago in the conveyance of the whole of the gold mining machinery required for the equipment of a mine situated in the heart of New Guinea. Much more can be done to-day. It is true that the aeroplanes used for such purposes are not designed for high speed. For a given overall weight they will naturally have to be more capacious than a large bomber and therefore they will be slower. Hence they will be very easily attacked. Their power of manœuvre will be slight, and their ability to put up a fight will be severely limited. Hence they can only be used over hostile country in daylight hours if the command of the air has already been attained, or if they are accompanied by an adequate guard of fighters. Their great advantage is their speed of movement. To reinforce a threatened point at 200 miles an hour instead of the usual advance "on the belly," may make, and often will make, all the difference between the success and failure of the enterprise of which it forms a part.

History will possibly record that the present aspect of the struggle in Western Europe is an instance of a race for time in which troop-carrying aircraft are playing a vitally important role. As we mentioned in our issue last September, the U.S.S.R. Government had demonstrated how large a load-carrying aeroplane could be, for it reported the first flight of the L.760, with a wing span of over 200ft., a total laden weight of 45 tons, and a planned capacity to carry 64 passengers over 900 miles. Although there may not be many aerodromes where such a craft could alight, its very existence serves to show that there is no aerodynamic obstacle to a considerable further growth in size and carrying capacity of troop-carrying aircraft, should such be needed. When aerodromes of sufficient size, and reasonably free from the effects of previous air bombing are available, troop carriers can land in the ordinary way. Where they cannot, the alternative of dropping troops and equipment by parachute is still possible, though but a second best. The speed of alighting with a parachute is equal to that of jumping off a wall at least six feet high and possibly much more, hence the risk of minor injury to personnel and material is a factor which must not be forgotten. And this assumes reasonable alighting ground, neither woodland nor marsh. The ideal troop-carrying aircraft would, no doubt, be one which could ascend with its full load without calling for any special aerodrome facilities and which could alight with equal freedom on any kind of ground whatever; when the helicopter is perfected something of the kind will perhaps be available, but that is not for to-day. At present it is difficult to get any of the several rotating wing types of aeroplane to carry any considerable load and still harder to ensure that in the event of failure of the power plant a safe landing can be made. Even the "Jumping Autogiro," free as it is from the last-named risk, seems to be a comparatively modest load carrier and, at best, its level speed compares poorly with that of conventional forms of aircraft.

Given conditions generally favourable to the enterprise, the speed at which numbers of troops can be moved by air is remarkable. Thus if the distance is to be 250 miles, making 500 on the round trip, the time taken in the air need be but two and a half hours and if half an hour be allowed at each end for loading, unloading and fuelling, the total time taken per trip is only three and a half hours. Four trips per aeroplane would mean a hundred men conveyed each day. Hence if 100 aeroplanes were available, 10,000 men could be conveyed daily: allow another 100 to cover the need to carry light armament, provisions and other stores, and to allow for mishaps, and one can see

at once how 200 aeroplanes of the right design, and available on the right spot and at the right moment, could bring an effective force into operation in the shortest possible time, and what is more keep them reasonably supplied from day to day—always provided that the defence required against aircraft attack was either negligible, or was provided by a convoy of a sufficient force of fighters.

Obituary

HERBERT JOHN WARD

MANY engineers will learn with deep regret of the death of Mr. Herbert John Ward, the late chairman of J. and E. Hall, Ltd., of Dartford, who was for many years a Member of Council and a President of the British Engineers' Association. He died on Thursday, May 2nd, at his home, The Mill House, Farningham, Kent. Mr. Ward will be long remembered for a charm of personality which endeared him to a wide circle of friends both in this country and abroad. Herbert John Ward was born in Belfast in January, 1870, and came to England for his education at St. Mark's School, Windsor (Hawtrey's). He continued his studies at Pembroke College, Cambridge, and graduated in mathematics, mechanism

H. J. WARD

and applied mechanics, taking his B.A. degree in 1891 and his M.A. in 1896. On leaving Cambridge in 1891 he became a pupil at the Belfast works of Harland and Wolff, Ltd., where he gained experience in the engine works, shipyard and drawing offices, studying also the commercial side of the business. He left Belfast for Liverpool in 1895, when he was appointed a member of the technical staff of Elder Dempster, Ltd., and was given charge of the organisation and development of the constructional side of the firm's business. In that capacity he gained a wide knowledge of the design and construction of different types of ships which served him in good stead in his later career. In 1901 he resigned his Liverpool appointment in order to take up the position of managing director of the firm of J. and E. Hall, Ltd., refrigerating engineers, of Dartford, Kent. Not long after his appointment, the untimely death of his colleague, Mr. Alexander Marcet, who since 1888 had been a partner in the firm, threw upon Mr. Ward the main responsibility of consolidating and improving the position which his firm had gained in the manufacture and installation of marine refrigerating equipment. To that task he bent all his energies, and it was in that field of activity that he made a name which will long be remembered in both the shipping and shipbuilding industries.

In connection with his work Mr. Ward travelled widely in America and India, and in this country and the Colonies. The progress made in the development of marine refrigerating plant was well summarised in a paper which he read before the Institution of Mechanical Engineers in February, 1929, entitled "Refrigeration on Shipboard," in which he traced the recent developments in marine refrigerating plant, particularly the progress made with the CO_2 machine. In that paper, Mr. Ward also made reference to the beginnings of the banana industry in this country, with which he was closely associated. In 1897 practically the only bananas which came to this country were from the Canary Islands and were carried in crates, as deck cargo only in very cold weather. In 1910 the late Sir Joseph Chamberlain, then Colonial Secretary, interested Mr. A. L. Jones (afterwards Sir Alfred Jones), who was then the head of Elder Dempster, Ltd., of Liverpool, in the possibilities of a subsidised line of steamers from this country to Jamaica, to carry bananas, with the object of helping the Islands, which were at that time suffering on account of the decay of their sugar industry. From small beginnings the trade grew, and in 1927 Mr. Ward stated in his paper the number of bunches of bananas brought from the Gulf ports to the United Kingdom had reached the figure of 18,109,000 a year, while the actual number of banana bunches carried on a single ship had reached the figure of 110,000. Even in the last ten years or so the banana trade has further increased, and much work has continued to be done in connection with the refrigerating side of the business by Mr. Ward's firm for British, Colonial and American fruit carrying firms. The advances made with electric and oil engine driven refrigerating plant have also led to the wider adoption of refrigerating plant aboard ship.

Mr. Ward was elected chairman of the company in 1921 and continued in office until 1937, when he retired owing to ill-health. Alongside his work at Dartford he found time to keep in close touch with the development of British industry and was a Member of the Council of the British Engineers' Association for many years and from 1925–28 its President. He was an honoured member of the Institution of Mechanical Engineers, the Institution of Naval Architects and the Institute of Marine Engineers. Those, like ourselves, who had the opportunity of meeting him on various occasions and travelling with him in ships will not readily forget his outstanding personality, his charm of manner and his retentive memory, which, as his successor at J. and E. Hall, Ltd., Lord Dudley G. Gordon, has well said, won him friendship and respect wherever he went.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

MECHANICAL EFFICIENCIES OF SIMILAR FANS AND PUMPS

SIR,—Last Spring, Mr. J. Jennings and the writer * discussed in these columns the "fluid" (*i.e.* the "manometric" and "hydraulic") characteristics of geometrically similar fans, blowers, and centrifugal pumps, from the point of view of dimensional analysis. This note may be regarded as a postscript to that discussion as it deals with the purely mechanical characteristics of these machines, as affected by bearing friction.

The power P_c supplied to the coupling of a single- or multi-stage fan, blower, or centrifugal pump is always greater than the power P absorbed by the impeller or impellers, by an amount P^b representing the power lost through friction in the bearings,

$$P_c=(P+P_b) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

P is used up by the impeller, for the most part, in imparting pressure, kinetic and positional energy or head to the fluid, the remainder being lost in the form of frictional reheat of the fluid. P_b is a purely mechanical power loss which appears as heat in the bearings.

The mechanical efficiency η_m is the ratio P/P_c of the impeller power P to the coupling power P_c, and it can be written,

$$\eta_m=1-(P_b/P) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

since P_b is usually small compared with P.

The overall efficiency, or efficiency η_c at the coupling, is the product $\eta\eta_m$ of the hydraulic efficiency η and the mechanical efficiency η_m,

$$\eta_c=\eta\eta_m \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The impeller power P of any member of a family of geometrically similar pumps can be written,

$$P=c_1\rho n^3d^5 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

provided the output coefficient q/nd^3 is constant for all members. Here c_1 is an experimental coefficient having the same, almost constant, value for all members, ρ is the density of the fluid, n is the speed of impeller rotation, and d is the impeller diameter. Actually c_1 varies slightly according to the "Reynolds number" of the flow in the machine and the "relative roughness" of the internal surfaces, but the variation is slight in ordinary cases.

The power P_b lost in the bearings of geometrically similar pumps can be represented closely by,

$$P_b=c_2s^{0\cdot6}n^{1\cdot6}d^{3\cdot4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

for film lubricated journal bearings, and,

$$P_b=c_3nd^{2\cdot2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

approximately for ball or roller bearings. c_2 and c_3 are small experimental constants common to all members of the family, and s is the coefficient of viscosity of the lubricating oil used in the bearings.

The mechanical efficiencies corresponding to these bearing friction powers follow from equations 2, 4, 5, and 6,

$$\eta_m=1-(c_4s^{0\cdot6}/\rho n^{1\cdot4}d^{1\cdot4}) \quad . \quad . \quad . \quad . \quad . \quad (7)$$

for film lubricated bearings, and,

$$\eta_m=1-(c_5/\rho n^2d^{2\cdot2}) \quad . \quad . \quad . \quad . \quad . \quad (8)$$

for ball or roller bearings.

The mechanical efficiency η_{m1} of a large pump (1) can now be expressed in terms of the mechanical efficiency η_{m2} of a geometrically similar small or model pump (2), provided $q_1/n_1d_1^3=q_2/n_2d_2^3$ by

$$\eta_{m1}=\eta_{m2}\left[1-c_4\left\{(s_1{}^{0\cdot6}/\rho_1n_1{}^{1\cdot4}d_1{}^{1\cdot6})-(s_2{}^{0\cdot6}/\rho_2n_2{}^{1\cdot4}d_2{}^{1\cdot6})\right\}\right] \quad (9)$$

for journal bearings, and

$$\eta_{m1}=\eta_{m2}\left[1-c_5\left\{(1/\rho_1n_1{}^2d_1{}^{2\cdot2})-(1/\rho_2n_2{}^2d_2{}^{2\cdot2})\right\}\right] \quad (10)$$

for ball or roller bearings.

Equations 7 to 10 represent the mechanical or bearing friction characteristics of similar machines, and serve to make clear the parts played by the various factors. They confirm, in symbols, that large multi-stage high-speed pumps dealing with dense fluids have higher mechanical efficiencies than small single stage low speed pumps dealing with fluids of small density.

G. G. MCDONALD, Ph.D.
The James Watt Engineering Laboratories,
The University, Glasgow, W.2.
April 30th, 1940.

* THE ENGINEER, Vol. 157 (1939).

A GRAPHIC METHOD OF OBTAINING LOGARITHMIC MEAN TEMPERATURE DIFFERENCES

SIR,—The simplest way of obtaining the logarithmic mean temperature differences required in heat-exchanger and condenser work is to look them up in a table, but those who prefer graphic methods may be interested in a peculiar property of the curve represented by the equation :

$$y=e^{1/x}\times x$$

To make use of the property in question it is necessary first to write the equation in the form :

$$x=\frac{1}{\log_e D} \text{ and } y=\frac{D}{\log_e D}$$

by introducing a parameter D which may be taken to denote the temperature difference at either end of the heat exchanger. It may then be made more practical by conversion to ordinary logarithms, and by introducing an arbitrary constant a, chosen so as to keep x nicely within the width of the paper for the smallest value of D with which we are concerned. With these alterations the equation becomes

$$x=\frac{a}{\log_{10} D} \text{ and } y=x\times\frac{D}{2\cdot3026\times a}$$

Corresponding values of x and y are now to be computed for each value of D in the range to be covered, and the points so found are to be plotted as a curve on squared paper. The various values of D are to be marked on the curve in their appropriate places.

Suppose now that D_1 and D_2 are the temperature differences at the inlet and outlet of any given heat exchanger, and that it is required to find the value of the logarithmic mean temperature difference D_m across the apparatus. All that has to be done is to lay a straight-edge across the points D_1 and D_2 on the curve, and the value of D_m can then be read off directly where the straight-edge cuts the axis of y, which is to be graduated uniformly to the same scale as x.

The proof of the proposition is too long to be given in these days of paper shortage, but the chart may be recognised as a sort of Nomogram in which two of the variables are represented by a single curved scale.

For the usual conditions of steam condensers D may be taken to range from 3 to 30 and for squared paper of the ordinary width of 18 cm. a convenient value of a for this range will be 8·5.

R. H. PARSONS.
May 6th, 1940.

Dynamic Effect of Incendiary Bombs on Roofs

By J. D. W. BALL, A. M. Inst. C.E.

ENCOURAGED by the classic example of the hanging carpet, which is said to be capable of stopping a rifle bullet, it may well be that inventors will soon devise an incendiary bomb-proof roof of reasonably light construction which lends itself readily to æsthetic treatment. Air Raid Precaution authorities recommended for this purpose a slab of reinforced concrete at least 4in. in thickness. The ordinary incendiary bomb, weighing about 2 lb., may strike the roof with a velocity as high as 400ft. per second. Experiments made by firing a suitable projectile with this velocity at a reinforced concrete slab show that, although there is local damage at the point of impact, the projectile is thrown back a considerable distance because the slab acts as a spring. The first step in computing the force of the blow is to determine the number of pounds of concentrated static load which, placed at the centre of the slab, would produce unit deflection, as this provides a measure of the stiffness of the spring.

Comparatively little prominence has been given to the problem of concentrated loads applied to slabs, in this country. Their effect has been taken into account in the preparation of the Ministry of Transport's standard loading for highway bridges, but without disclosing how this has been done. The results of the investigations of the French engineer, M. Pigeaud, have been made available by Mr. W. L. Scott in his articles and in his book

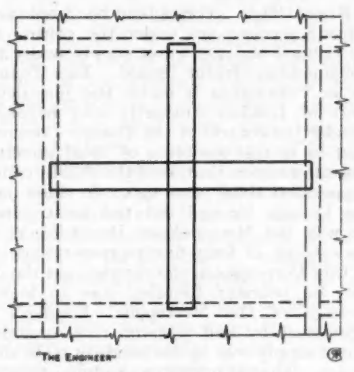

FIG. 1

on reinforced concrete, and various American text-books give the results of investigations carried out in the United States. In all these cases the load is actually distributed, in the first place over the considerable area of contact between wheel and road surface, and in the second place by the effect of the road surface material. An incendiary bomb striking a roof slab provides an almost perfect example of a truly concentrated load. As the investigation applies to an isolated live load, unbalanced by any other live load in adjoining panels, it will be in accordance with usual practice to consider the edges of the slab as simply supported.

Two cases will be considered:—(*a*) a slab supported on four sides forming a panel 10ft. square, and (*b*) a slab of 10ft. span supported on two sides only. The bomb will be assumed to strike at the centre of the panel or slab in each case. There are two unknown features, namely, the force of the blow and the effect of dispersion, and to commence the investigation of case (*a*), a narrow strip at the centre of the square panel will be considered to be carrying a knife-edge load at the centre of 1 lb. per ft. width in either direction as shown in Fig. 1. The bending moment diagram corresponding to these strips is illustrated in Fig. 2, the value of the centre ordinate being $\frac{1}{4}wl$, or $\frac{1}{4}\times1\times10=2{\cdot}5$ft. lb. per ft. width. The deflection curve is determined by graphic integration, successively summing the areas of the bending moment diagram, and the resulting inclination curve as set out in Table I.

Half the total load which is carried to the supports in one direction is evidently distributed in the other direction proportionately to the deflection curve, because the load carried by any particular strip must be proportional to the deflection of that strip. The dotted lines in Fig. 2 show a rectangular area equal to that included by the deflection curve, and as the ordinate of this rectangle represents the maximum deflection and the width is equal to 6·25ft., it is evident that each half of the concentrated load, which is carried in one or other direction, is in

TABLE I.—*Areas of B.M., Inclination and Deflection Curves drawn in Fig. 2.*
(Half span only. Ft. lb. units.)

Ordinates B.M. diagram at intervals of 1ft.	Partial areas	Sum of areas	Allow for constant −6·25	Partial areas inclination curve	Sum of areas	Partial areas deflection curve
0	—	0	−6·25	—	0	—
—	0·25	—	—	6·17	—	3·09
·5	—	0·25	−6·00	—	6·17	—
—	0·75	—	—	5·66	—	9·07
1·0	—	1·00	−5·25	—	11·83	—
—	1·25	—	—	4·67	—	14·27
1·5	—	2·25	−4·00	—	16·50	—
—	1·75	—	—	3·17	—	18·23
2·0	—	4·00	−2·25	—	19·67	—
—	2·25	—	—	1·16	—	20·43
2·5	—	6·25	0	—	20·83	—
				Half total		65·09

NOTE.—Half effective width of distribution equals 65·09÷20·83=3·125ft.

effect uniformly distributed over a width of 6·25ft., or five-eights of the span. In order to obtain an actual deflection or stiffness ratio, the load will be applied to a slab, 4in. thick, reinforced in

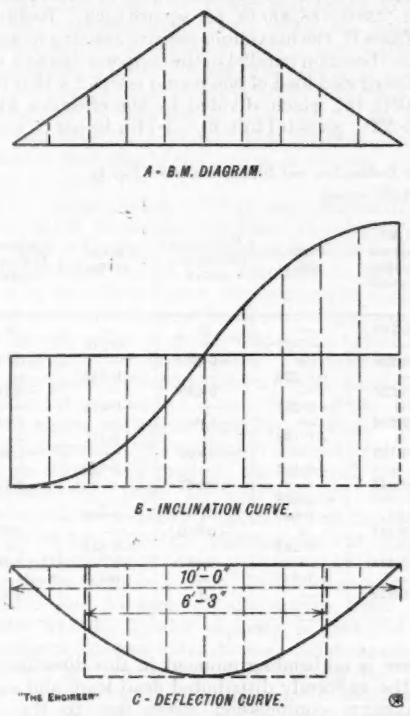

FIG. 2

each direction with $\frac{1}{2}$in. diameter rods at 5in. centres. The equivalent section of one foot width of this slab is shown in Fig. 3, and the moment of

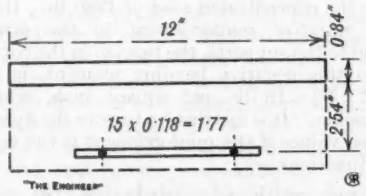

FIG. 3

inertia is equal to $\frac{1}{3}\times12\times0{\cdot}84^3+15\times0{\cdot}118\times2{\cdot}54^2=13{\cdot}8$in.^{4} units. One pound distributed over a width of one foot produces a deflection of

$$20{\cdot}83\times12^3\div(2{,}000{,}000\times13{\cdot}8)=0{\cdot}0013\text{in.}=0{\cdot}000108\text{ft.}$$

Therefore a concentrated load of 12·5 lb. carried half in each direction will result in 6·25 lb. being distributed over a width of 6·25ft. and the deflection will be 0·000108ft. giving a stiffness ratio of 12·5÷0·000108=116,000 lb. per ft.

A spring in the form of a slab carrying the uniformly distributed load of its own weight does not present a very tractable problem, but a beam carrying a uniformly distributed load has the same deflection at the centre as the same beam carrying a central concentrated load of five-eights the amount, and a slab carrying a uniformly distributed load has the same deflection at the centre as the same slab carrying a central concentrated load equal to five-eights squared, or 0·39 of the distributed load. The curve shown in Fig. 2 (*c*), not only represents the deflection of a central strip of the slab, but may also be used as a velocity and retardation curve, because if the central ordinate represents to a convenient scale the velocity, at any instant, of the centre of the slab, due to the impact of the bomb, other ordinates will represent to the same scale the velocity of corresponding points of the slab, and the same applies to retardation. From a consideration of the dotted area in Fig. 2 (*c*) it can be proved that the con-

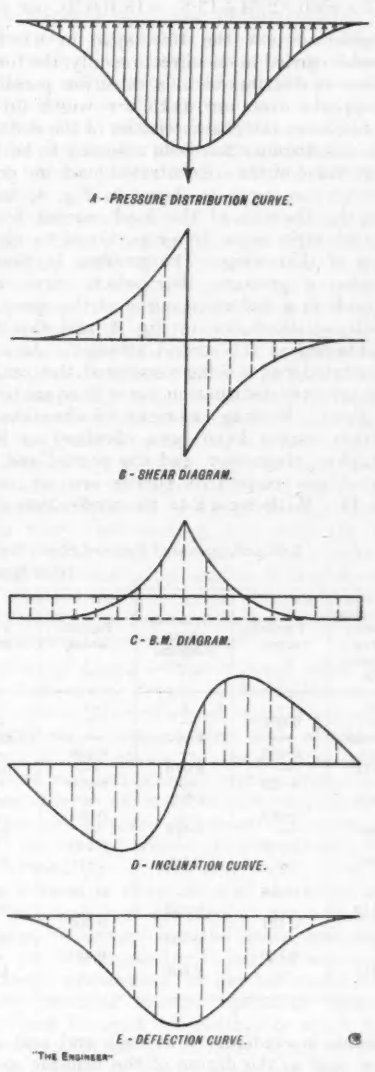

FIG. 4

centrated mass of 0·39 W with a velocity (v) will have the same momentum as the whole slab with a velocity varying from zero at the edges to a maximum velocity of (v) ft. per second at the centre. The weight of this equivalent concentrated mass in the case under consideration is $6{\cdot}25\times6{\cdot}25\times50=1953$ lb. On the two main considerations indicated, the slab is equivalent to a spring having a stiffness factor of 116,000 lb. per ft., loaded with a concentrated weight of 1953 lb. When the 2 lb. bomb with a velocity of 400ft. per second strikes, in effect, this concentrated mass it communicates to it an initial velocity (v) which can be calculated from the usual impact formula. The coefficient of restitution (k), of metal on concrete under test conditions is about 0·37.

$$\begin{aligned}v&=(1+k)\,wu\div(w+\text{W})\\&=1{\cdot}37\times2\times400\div(2+1953)\\&=0{\cdot}56\text{ft. per second.}\end{aligned}$$

The kinetic energy of this mass of 1955 lb., with a velocity of 0·56ft. per second, added to the work done by the force of 1955 lb. moving through the resulting deflection (y) of the spring, must equal the energy stored up in the spring. The

resistance of the spring at the moment of impact is 1955 lb. and at the lowest point $(1955+116{,}000y)$ lbs., $\therefore \frac{1}{2}\times1955\times0{\cdot}56^2\div32+1955y=\frac{1}{2}(1955+1955+116{,}000y)y$ and $y=0{\cdot}0128$ft. The force producing this deflection is $116{,}000\times0{\cdot}0128=1485$ lb.

The stresses in the reinforced concrete slab can now be worked out, and as the moment of inertia of the equivalent section has already been determined, this will be used in completing the calculations. The figures refer to an end panel in which half the dead load may be considered to be carried in either direction, producing a maximum positive bending moment equal to $\frac{1}{2}wl^2\div10$. B.M. per ft. width due to dead load

$=\frac{1}{2}\times50\times10\times120\div10$ =3000 in. lb.

B.M. per ft. width due to live load

$=\frac{1}{2}\times1485\times120\div(4\times6{\cdot}25)$ =3560 in. lb.

Total ... ... 6560 in. lb.

Maximum compression in concrete

$6560\times{\cdot}84\div13{\cdot}8$ =400 lb. per sq. in.

Maximum tension in steel

$=15\times6560\times2{\cdot}54\div13{\cdot}8$ =18,100 lb. per sq. in.

Considering now the 10ft. span in which all the load is carried in one direction only, the force of the blow is distributed in a direction parallel to the supports over an unknown width (a). In order to obtain the characteristics of the deflection curve, this distance has been assumed to be 16ft., and the value of the concentrated load one pound. The deflection curve is shown in Fig. 4, and as before the fraction of the load carried by any particular strip must be proportional to the deflection of that strip. The problem is, then, to determine a pressure distribution curve which will result in a deflection curve of the same form as itself, as illustrated in Fig. 4, and this result was obtained at the second attempt. As a unit concentrated load is being considered, the total area of the pressure distribution curve is equal to 1 lb. The shear, bending moment, inclination and deflection curves have been obtained as before by graphic integration, and the partial and total areas of the respective curves are set out in Table II. With regard to the inclination curve, the value is evidently 0 at each end and at the centre, and so the datum of the bending moment diagram has been adjusted, equivalent to the inclusion of a constant equal to the area of the original bending moment diagram divided by the length, 16ft.

In order to obtain actual results the reinforcement must be determined provisionally and corrected if necessary, and the following figures are worked out on the basis of $\frac{1}{4}$in. diameter rods at 3in. centres in the direction of the 10ft. span, and $\frac{3}{16}$in. diameter rods at 6in. centres parallel to the supports. The percentage of main reinforcement is 0·48, and the neutral axis 1·07in. from the compression surface. The moment of inertia of a 1ft. width of the equivalent section is $\frac{1}{3}\times12\times1{\cdot}07^3+15\times0{\cdot}196\times2{\cdot}31^2=20{\cdot}6$in.^{4} units. The percentage of the distribution reinforcement is 0·145, and the neutral axis 0·59in. from the compression surface. The moment of inertia of 1ft. width of this section is $\frac{1}{3}\times12\times0{\cdot}59^3+15\times0{\cdot}055\times2{\cdot}56^2=6{\cdot}23$in.^{4} units. If the width over which the effect of the concentrated load is distributed is (a) ft. instead of 16ft., the maximum ordinate of the load or pressure diagram will be $0{\cdot}142\times16/a=2{\cdot}27/a$, and the effective width of distribution is equal to the total load, 1 lb., divided by this maximum ordinate, the result being $0{\cdot}44a$. Referring to Fig. 2 and Table I, a load of 1 lb. per ft. width on a 10ft. simply supported span produces a deflection of $20{\cdot}83\times12^3\div(2{,}000{,}000\times20{\cdot}6)=0{\cdot}000874$in. Therefore a concentrated load of 1 lb., the effect of which is distributed over an effective width of $0{\cdot}44a$ft. would produce a deflection of $0{\cdot}000874/0{\cdot}44a=0{\cdot}00199/a$in. In the direction parallel to the supports a point load of 1 lb., distributed over an effective width of 6·25ft., produces a deflection of $4{\cdot}86\times12^3\div(2{,}000{,}000\times6{\cdot}23\times6{\cdot}25)=0{\cdot}000108$in. on a span of 16ft. and $0{\cdot}000108a^3/16^3$ on a span of (a) ft. These deflections must be equal and therefore $0{\cdot}00199/a=0{\cdot}000108\ a^3/16^3$ or $a=16{\cdot}6$ft. and the deflection due to 1 lb. $=0{\cdot}00199/16{\cdot}6=0{\cdot}00012$in. $=0{\cdot}00001$ft. The stiffness of the spring in this case is 100,000 lb. per ft. The effective width of distribution in the direction parallel to the supports is $0{\cdot}44\times16{\cdot}6=7{\cdot}3$ft., and the weight of the equivalent concentrated mass, which will have the same momentum with velocity v ft. per second as the actual moving mass with a maximum velocity of v ft. per second, is $6{\cdot}25\times7{\cdot}3\times50=2280$ lb. Proceeding as before, the initial velocity (v) communicated to the slab at the point of impact is $1{\cdot}37\times2\times400\div(2+2280)=0{\cdot}48$ft. per second. Equating the kinetic energy and work done by the deflecting slab to the energy stored up in the slab:—$\frac{1}{2}\times2282\times0{\cdot}48^2\div32+2282y=\frac{1}{2}(2282+2282+100{,}000y)y$, determines the value $y=0{\cdot}0128$ft., and the force of the blow $=100{,}000\times0{\cdot}0128^2=1280$ lb.

The bending moment in the direction of the span due to a unit concentrated load is $\frac{1}{4}\times1\times120\div7{\cdot}3=4{\cdot}11$ in. lb. per ft. width, and the bending moment due to a concentrated load of 1280 lb. $=4{\cdot}11\times1280=5260$ in. lb. per ft. width. The bending moment due to the dead load in an end panel is equal to $\frac{1}{10}\times500\times120=6000$ in. lb. per ft. width, making a total positive moment of 11,260 in. lb. This gives a maximum compression stress in the concrete of $11{,}260\times1{\cdot}07\div20{\cdot}6=585$lb. per square inch and tension in the reinforcement equal to $15\times11{,}260\times2{\cdot}31\div20{\cdot}6=18{,}900$ lb. per square inch. Referring to Table II, the maximum positive bending moment in the direction parallel to the supports due to a unit concentrated load of one pound is $0{\cdot}872\times16{\cdot}6/16=0{\cdot}905$ft. lb., which, divided by the effective width of 6·25ft., gives 0·145ft. lb. $=1{\cdot}74$in. lb. per ft. width. There is no bending moment in this direction due to the uniformly distributed dead load, and so the maximum compression stress due to the concentrated load of 1280 lb. is $1280\times1{\cdot}74\times0{\cdot}59\div6{\cdot}23=121$ lb. per square inch, and the tension in the steel $15\times1280\times1{\cdot}74\times2{\cdot}56\div6{\cdot}23=13{,}700$ lb. per square inch. The negative bending moment per ft. width $=0{\cdot}23\times16{\cdot}6\div(16\times6{\cdot}25)=0{\cdot}038$ft. lb. for a unit load, and $0{\cdot}038\times1280=49$ft. lb. $=588$in. lb. for the concentrated load of 1280 lb. If there is no negative reinforcement in the direction parallel to the supports, the tension in the concrete, due to this negative bending moment, is $588\div(\frac{1}{6}\times12\times4^2)=18$ lb. per square inch, which is permissible. It is instructive to note the difference in these values if the reinforcement is the same in both directions :—

- Total width of distribution (a) = 22·4ft. instead of 16·6ft.
- Effective width of distribution = 9·87ft. instead of 7·3ft.
- Deflection due to 1 lb., 0·0000074ft. instead of 0·00001ft.
- Stiffness of spring, 135,000 lb. per ft. instead of 100,000 lb./ft.
- Equivalent mass 3090 lb. instead of 2280 lb.
- Velocity (v) 0·35ft. per second instead of 0·48ft. per second.
- Deflection due to blow 0·009ft. instead of 0·0128ft.
- Force of blow 1210 lb. instead of 1280 lb.
- B.M. under unit load (direction of span) 3·04in. lb. per ft. instead of 4·11in. lb. per ft.
- B.M. under unit load (parallel to supports) 2·34in. lb. per ft. instead of 1·74in. lb. per ft.

The equivalent uniformly distributed load which would produce the same maximum bending moment as a concentrated load of 1485 lb., at the centre of a panel, 10ft. square, supported on four sides, is 47·5 lb. per square foot. In the case of the slab supported on two sides only, and with the main and distributing reinforcement as specified the equivalent uniformly distributed load is 35 lb. per square foot. For flat, or nearly flat, roofs, the usual live load of 50–56 lb. per square foot allowed for in design is therefore more than sufficient to cover the effect of an incendiary bomb. In the case of inclined roofs, for which the usual live load allowance is less, the stresses produced by an incendiary bomb would not be dangerously high.

The beams supporting the slab constitute stiffer springs, and the force of the blow will therefore be greater. Actual values can be calculated in a similar manner to that adopted for the slab.

TABLE II.—*Areas of Pressure, Shear, Bending Moment, Inclination, and Deflection Curves (Fig. 4)*
(Half Span only. Ft. lb. units.)

Ordinates pressure curve 1ft. intervals	Partial areas	Ordinates shear diagram	Partial areas	Total areas	B.M. diagram including constant	Partial areas	Ordinates Inclination curve	Partial areas	Ordinates Deflection curve
0	—	0	—	0	−0·230	—	0	—	0
—	0·001	—	0	—	—	−0·23	—	−0·115	—
0·0035	—	0·001	—	0·000	−0·230	—	−0·23	—	−0·115
—	0·009	—	0·004	—	—	−0·229	—	−0·345	—
0·014	—	0·010	—	0·004	−0·226	—	−0·459	—	−9·46
—	0·022	—	0·020	—	—	−0·219	—	−0·572	—
0·031	—	0·032	—	0·024	−0·206	—	−0·678	—	−1·032
—	0·044	—	0·053	—	—	−0·182	—	−0·772	—
0·055	—	0·076	—	0·077	−0·153	—	−0·860	—	−1·804
—	0·068	—	0·107	—	—	−0·107	—	−0·920	—
0·082	—	0·144	—	0·184	−0·046	—	−0·967	—	−2·724
—	—	—	—	—	—	−0·008	—	—	—
—	0·096	—	0·190	—	—	+0·045	—	−0·966	—
0·110	—	0·240	—	0·374	+0·144	—	−0·930	—	−3·69
—	0·121	—	0·300	—	—	0·283	—	−0·819	—
0·132	—	0·361	—	0·674	+0·444	—	−0·647	—	−4·509
—	0·139	—	0·428	—	—	0·647	—	−0·354	—
0·142	—	0·500	—	1·102	+0·872	—	0	—	−4·863

Sixty Years Ago

London's Water Supply

The local government of London presents to this day an amazing picture of diffused authority. The London County Council exercises its functions over an area comprising twenty-seven boroughs and one city—the City of Westminster. Near the centre of this area the Corporation of the City of London holds sway over one square mile east of Temple Bar. The City Police Force is administered by the Corporation, but elsewhere the police are under the government of the Home Office. Throughout the whole area the fire brigade services are under the control of the County Council and the water supply under that of the Metropolitan Water Board. The Thames as far up as Teddington is under the jurisdiction of the Port of London Authority and beyond that point under the control of the Thames Conservancy. Complex as is this structure of local government, it represents a rationalisation of the chaotic conditions which prevailed sixty years ago. In those days the London County Council did not exist. Its forerunner was the Metropolitan Board of Works, a body consisting of forty-five representatives elected by the City Corporation, the vestries and the district boards. Its primary function was to look after the sewage of the Metropolis. London's docks were governed by half a dozen rival organisations and water supply was in the hands of eight different companies. The fire brigade was administered by the Board of Works, but it had no understanding with the water companies and between it and the police there was little co-operation. Writing on the subject generally and on the water supply aspect of it in particular we said, in our issue of May 14th, 1880, that London had authorities innumerable; but still there was a lack of authority. Were not the people better than the system? In seven years London would be desolation. Continental cities with British institutions could never exist. The water supply system had brought the subject to an acute head. A Government Bill had been introduced into Parliament making provision for the creation of an entirely new body to control the supply, but the price to be paid to buy out the existing water companies excited opposition, the Government suffered a defeat, and Parliament was dissolved—"dissolved in water," as a wit declared. The water companies, although private organisations, were subject to a certain measure of control, exercised in part by the Local Government Board and in part by the Metropolitan Board of Works. There was a strong feeling that the Board of Works ought to be made the authority for the supply of London's water. It was argued that the body which got rid of the dirty water ought to be responsible for bringing in the clean. The Board, however, refused to act in the matter. Londoners were half amazed to find that their town had apparently no governing body properly adapted to take the place of the water companies. They were concerned with the subject not only from the administrative standpoint, but also from that of the practical efficiency of the supply. Two points in particular drew their criticism: the failure of the companies to provide a continuous supply of water uniformly throughout their areas—intermittent supply with tank storage by the consumers still being common—and the absence of high pressure hydrants in the streets for fire-fighting purposes. . . . Time went on without a practical solution of the problem being brought much nearer. In 1888 the London County Council was created to take the place of the Board of Works. The Metropolitan Water Board in which the powers and duties of the old water companies were merged was established in 1904.

Mastering Momentum in Transport*

By L. K. SILLCOX†

No. I

Fundamentals.—Deprive the mechanical engineer who is responsible for the control of mass in motion, of two fundamental equations:—

$$F = \frac{Wa}{g}$$

and

$$Ek = \frac{WV^2}{2g}$$

and he would become no more than the handy man of the machine industries, without technical leadership at his instant call, fearful of the integrity of every design, and falling into the practice of testing his constructions without end The factors in the two basic equations are, of course:—

F=force—pounds.
W=weight—pounds.
a=rate of acceleration—feet per second per second.
g=rate of acceleration impressed upon a body by gravity=32·2ft. per second per second, approximately.
Ek=kinetic energy—foot pounds.
V=velocity of the weight W—feet per second.

These finite relationships, together with time and distance combinations defining velocity and acceleration, linear or in a curved path, underlie all the work which the engineer is required to perform in predicting forces and their orbits of influence, permitting intelligent and economical design. They invade, almost without exception, the data sheets which he prepares in the process of solving his problems in dynamics.

Individual Problems.—The specialist in every field is inclined to believe that the problems presented to him are extraordinarily complex, requiring the most exacting treatment and presented in the greatest variety, of any with which the profession is confronted. Rolling mill equipment may deal with vast pressure and high temperatures; packaging machinery may call for utmost precision; the automotive industry may operate with least permanence in the designs which are final for only a day, but it is doubtful that any enterprise embraces in the breadth of its engineering interests the progression of technical detail that is to be found in the equipment which constitutes a railway train.

Motive Power Engineering.—The example of the modern reciprocating steam locomotive is impressive. As it stands immobile upon the rails, it comprises an efficient power plant of high capacity, sufficient to evaporate 100,000 lb. of water per hour and deliver it, superheated, at 300 lb. per square inch pressure. Precision built, high speed turbines propel electric generators for lighting and train control, others drive efficient pumps for the delivery of feed water, preheated, to the boiler. Materials handling methods contribute the screw conveyor which transfers coal from the tender to the distributing plates whence pressure jets disperse it uniformly over the grates. The service of a hidden reciprocating type steam engine is called upon to drive this mechanism which incorporates a crusher zone for conditioning the coal fuel and intercepting damaging waste which would obstruct the system. Extremely rugged, trouble free, direct-acting compressors furnish air under pressure for the operation of brakes and various auxiliaries. The whole assembly rests upon an integral steel casting which may weigh nearly fifty tons without setting any new records for the part. Now set the mass in motion and it becomes a powerful vibrant, living thing, straining at every co-ordinated detail of its structure to exert a force of 80,000 lb. at its drawbar or deliver as much as 6000 H.P. at a speed of perhaps 90 m.p.h.

Supervision in Service.—Again, the railway mechanical engineer occupies the unique position that not only does he dictate the design of the equipment adopted, but he is also responsible for its operation and maintenance. In short, he must be equipped with knowledge of combustion, chemistry of feed water treatment, metallurgy, hydrodynamics, thermodynamics, strength of materials, applied mechanics, lubrication, and practical machine and structural design. All this is required for power production, nor may he exceed limitations of dimensions, weights, and dynamic forces delivered outside the locomotive structure—the reactions which give his locomotive a foothold upon the rails—which are set down for him by other capable railway engineers who build and maintain the track structure over which the locomotive will run.

Diversity of Interest.—The modern steam locomotive is a monumental work, born of the co-ordinated efforts of many men but known in every detail and function by the mechanical department head of each of the great railway systems. His responsibility and influence extend further. Cars, both freight and passenger, are acquired only after he is satisfied as to the integrity of their structures, the fitness of their suspension systems, and the suitability of all the fittings with which they are equipped: air brakes, draught gear, heating system, lighting, refrigeration of freight cars and air-conditioning of passenger units. Rail motor-cars, Diesel switchers and perhaps Diesel road locomotives, electric locomotives, and multiple unit equipment on terminal, mountain grade, and heavy traffic lines are all his charges, each presenting its attendant problems by virtue of its own peculiarities and those of the auxiliaries with which it is fitted. It would be difficult indeed for a mechanical engineer in another field to claim broader knowledge or a more diversified list of first interests. When a detail as simple in form and construction as a railway car wheel can present almost unlimited field for study and choice, the opportunity for long hours of labour and trying demands upon time and resourcefulness are not wanting in those who have brought the designs of railway equipment to their present development. It is true the railway mechanical engineer seldom designs and builds his equipment without consulting the recommendations of specialised engineers of the allied industries, the manufacturers who supply him, but in the final analysis it is his judgment that governs and his decision that charts the course of railway equipment progress.

Locomotive Design.—Before any locomotive is constructed, its assignment is laid down, expressed in terms of tonnage to be hauled, speed to be regularly operated, grades to be encountered, and total time to be allowed over the locomotive division. The engineer in charge of track and bridges specifies maximum values in gross weight, individual axle loading, and dynamic augment. Turntable size and structure clearances may restrict overall dimensions. Nature of curvature on the line affects wheel arrangement and the articulation of frames. With this information, the minimum number of driving wheels which will produce the required tractive capacity and their arrangement are selected. The speed to be operated under varying conditions of grade and specified tonnage dictates driving wheel diameter and the size of boiler to be installed. The boiler affects weight distribution and the number and location of idle engine truck and trailer wheels. Tender capacity is governed by location of coal and water stations and demands for non-stop performance as indicated by the prospective schedule. Up to this point in locomotive design there is little opportunity for the expression of individuality as long as the designer strictly adheres to conventional solutions but, satisfied as to fundamentals, no end of latitude is offered. From size and style of grate to smokebox, the efficiency of combustion depends upon his judgment and ingenuity, and from dry pipe and throttle to the exhaust nozzle, he stands responsible for the extraction of useful work from the steam which his boiler generates. There are very few poor locomotive designs and one individual locomotive specimen does not vary materially from another of contemporary design, but a vast difference is apparent between the locomotive constructed today and that which was built ten years ago. Design progress, independently conceived and improved by many men, moves along much the same line, irrespective of the name of the railway acquiring the latest examples of the type. That most of the new locomotives of any period bear marked resemblance, one to the other, arises less from the fact that the designers work in close harmony and co-operation than that each forward step represents logical advance based upon experience with older patterns and improvements in the materials and auxiliaries which may be utilised.

Locomotive in Motion.—The new locomotive appears on the rails at the head of its train. In passenger service, it may be called upon to haul as much as 1500 tons at 90 m.p.h.—in freight service, 16,000 tons at forty. With the opening of the throttle, reverse lever "in the corner," the new locomotive is creating momentum, the product of mass and velocity. As momentum increases, so does the kinetic energy stored in the train, but at a faster rate. Momentum increases directly with the speed. Internal energy in the fuel is converted into kinetic energy of motion at a rate proportional to the square of the speed. Parasitic motions dissipate energy in the direction of travel, in its opposite direction, vertically upward and vertically downward, transversely, right and left. Spring action, recoil, dynamic vector of rotating masses pointing in every direction, the scraping of flanges, the rubbing of diaphragms, bolsters, journal boxes, and coupler faces, the deflection of rails and movement of ties, noise, are evidence of wasted energy—burned fuel that hauls no tonnage and earns no revenue. The mechanical engineer, given a profile and line of unavoidable imperfection, then attacks his problem of so improving upon predecessor designs that many sources of lost effort will be minimised and others eliminated. Fortunately, his efforts are rewarded by reduction of waste and, no less important, the attendant benefits of quiet operation, superior riding qualities, lower track reaction, and decreased maintenance expense.

Involuntary Losses.—A train, operating upon straight, level track at constant speed, basically represents, with its locomotive, a mechanical construction of zero efficiency. Its function is to transport revenue tonnage and many derivations of physics are built up from the established truth that no work need be performed to maintain mass in a uniform condition of rest or motion. Then the reciprocating steam locomotive, no more than 7 per cent. efficient in itself, transforms the available fraction of heat in the fuel with which it is fired, only to again convert its mechanical equivalent into unavailable forms of energy in heat and noise. Work is being done upon the cars which carry the tonnage, not upon the lading itself. Useful work is confined to acceleration, guiding, and raising the load to higher elevations. The inherent losses in locomotive and cars must be suffered, but tremendous strides have been made in modifying them in degree.

Voluntary Losses.—Superimposed upon all the energy absorbing details in locomotive and car construction, the mechanical engineer is compelled to install an air brake system and, whereas he is diligent in his efforts to reduce the retarding effects of rail and journal friction with all these kindred forces, he is oftentimes impatient with the time and distance consumed in the dissipation of all the energy which has been installed with vast expenditure of fuel and water. The brake manufacturer, in recognition of the trend toward heavier trains, ever destined to move faster, has projected his research into the future, ready to fulfil needs yet unexpressed. In all his active study and design preparation, he has had to be mindful of the practical railway operation limitations with which he must not conflict or which he, by the very merit of his devices, must remove or modify. There is, for example, the use of steel on steel for supporting the load upon the ground.

Deceleration Limits.—A retardation rate equal to g, the rate of acceleration impressed by gravity upon an unresisted body, 32·2ft. per second per second, has been obtained in automotive experience with pneumatic tyres gripping the rough surface of a concrete pavement. This requires an available coefficient of friction between the tyre and road of 100 per cent., interpreted to mean that the force resisting sliding is equal to the weight with which the vehicle bears upon the roadway. Under the most favourable conditions which a well-sanded rail can provide, 40 per cent. adhesion values are seldom realised and, practically, much lower values must be considered in railway equipment design. Without actually gearing the wheels to the rails after the fashion of the cog railways, and assuming that existing design practice cannot require an adhesion condition in excess of 50 per cent. of the maximum obtainable, the retardation rate cannot exceed 6·4ft. per second per second or 4·4 m.p.h. per second, calling for a level of braking well in excess of any practiced upon railways today where the retarding force is derived from the use of pneumatic brakes, unsupplemented by any of the dynamic forms. The next limitation in

* A Discussion of Modern Transport Trends and their Influence upon the Equipment of American Railways, Massachusetts Institute of Technology, 1940.

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the latitude given the air brake engineer is the necessity for furnishing brake units which will function in a thoroughly reliable and predictable manner in association with other air brake units, despite variable conditions of weather and the type and weight of the cars upon which they are mounted. The third material limitation is found in the necessity for providing a type of mechanism which is indifferent to inexpert maintenance, in so far as its basic functions are concerned, and one which will operate successfully over long periods of time with no maintenance attention whatever.

(To be continued)

Machine for Planing Marine Propellers

TO cut screw threads with an outside diameter of 20ft., a root diameter of 4ft. and a pitch of 20ft. is an actual requirement in the manufacture of marine propellers. To develop such a surface economically and accurately the special propeller planing machine illustrated herewith and on page 456 was supplied to a specification drawn up by the Manganese Bronze and Brass Company, Ltd., London, by the Morton Manufacturing Company, Michigan, U.S.A. The machine was designed in collaboration with the purchasers to carry out the following operations: radial planing, rotary planing and milling, and drilling.

The machine has a solid base plate on which is mounted a large diameter rotatable work-table, and a vertical column fitted with guides to carry a saddle moving in a vertical plane. Provision is made, through change gears, for the rotation of the work-table to be linked to the vertical movement of the saddle, power for both motions being obtained from a single source. Mounted on the saddle is a large rectangular forged steel ram reciprocated by means of a reversing planer-type motor, driving through gears to a solid-cut rack on the ram. The saddle can be set to incline the ram for working on a propeller, the blades of which are not at right angles to the shaft axis. The ram is bored hollow, and in it is mounted a forged steel arbor rotating in roller bearings, provision being made for thrust loads. This arbor, which is driven by a variable speed motor through reduction gearing is bored with a tapered end for receiving face mills or drills, and it also serves as a drive for a right angle milling head which can be mounted on the end of the ram and operated with its spindle at any angle.

The rheostats and contactor equipment for controlling the various motions are housed in a steel cubicle. Two rheostats are provided for controlling the ram motion in either direction, a third for the motor driving the arbor, another to control the continuous feeding rate of the feed motor, whilst a further two control the driving motor used for reciprocating the work-table in rotary planing. A pendant portable push button station is arranged between the steel cubicle and the work-table. The ram motor, which is rated at 10 H.P. at 500 r.p.m., is of planer-type design, and has a small armature to assist in rapid reversal. The same motor is used to drive the work-table when rotary planing is being done. For radial planing the work-table is connected to a 10 H.P. feeding motor with a variable voltage control giving a speed range of 12 r.p.m. to 1200 r.p.m.

True screw propellers are planed in the following manner:—The rotation of the work-table and the vertical motion of the saddle are geared together so that for each increment of rotation of the work-table the saddle rises a proportionate amount. If the ram is fixed so that it can only rise vertically as a unit with the saddle, a tool set in the ram generates the path of a true helix. If the cutting tool is then caused to reciprocate while the saddle is allowed to move incrementally relatively to the table on the return stroke of the ram, the cutting tool will develop a helical plane surface, which is, in fact, the working surface of a constant pitch propeller. The operation described above is radial planing, and cutting can be either draw-cut or push-cut. For rotary planing the rotation of the work-table is used as the driving force, the ram acting as a tool holder, and the cut is taken circumferentially.

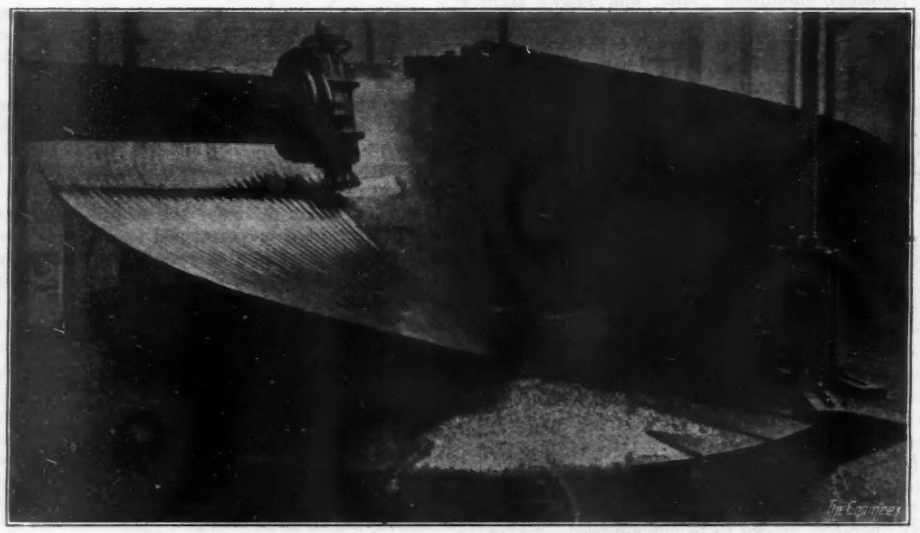
When planing radially the length and position of the cutting stroke are controlled by the appropriate positioning on a "T" slotted circular rotating disc of tappet blocks which engage and operate stroke limit switches. When rotary planing is in process similar tappet blocks, operating limit switches, are set in a "T" slot around the work-table. The work-table is graduated in degrees and minutes, and provided with a vernier for accurate setting of the machine from one blade to the next.

The foregoing remarks deal with the planing of true-screw propellers, but as pitch variations and curved blades (*i.e.* curved from tip to root) are coming more and more to the fore, it is necessary to describe how these are machined. When the blade has a straight centre line, with a combination of constant pitch on the outer sections and varying pitch towards the root, the operation is carried out in three stages. First, the outer portion of constant pitch is planed; then datum lines for the remainder of the blades are milled at the appropriate pitch for each radius; finally the ridges between the milled grooves are ground down. Where the entire pitch varies, and the blade is curved or dished, a curved centre line is cut accurately by hand to a template, and grooves are then milled to the correct pitch intersecting this prepared datum line, as shown in the engraving on this page. When the milled grooves are spaced 1in. apart, the intervening ridges are about 0·01in. high, and are easily ground off with a cup emery wheel in a portable machine. The inserted-blade milling cutter used is 8in. diameter, the feed varying from 20in. to 30in. per minute according to the depth of cut.

A wide range of cutting and return speeds is provided by means of the Westinghouse-Electric variable voltage reversing planer motor and control. The cutting speeds range from 14ft to 100ft. per minute in either direction, and there is a special slow speed of 1½ft. per minute for inching the ram into position. This type of drive is particularly advantageous for short strokes as it is possible to get as many as forty 6in. strokes per minute. For both incremental and continuous feeding the work-table is actuated by a variable voltage motor. Incremental feeds are controlled by a relay, measuring actual motor revolutions, which stops and starts the feed motor through suitable electrical connections at each reciprocation of the ram. The minimum incremental feed provided is equivalent to $\frac{1}{64}$in. on 15ft. diameter, the corresponding maximum being approximately $\frac{15}{16}$in. Continuous feeding rates such as would be used in milling cover a range of 2in. to 12in. per minute at 3ft. diameter.

For setting-up purposes the table motion has a fast traverse speed of 60ft. per minute, and a slow speed of 0·6ft. per minute for spotting. The rotary planing speeds range from 15ft. to 45ft. per minute, and from 45ft. to 60ft. per minute for return. All these rates are for 15ft. diameter. The machine is equipped with approximately 100 change gears, and can develop any required pitch, at intermediate intervals of ¼in., over a range from 6ft. to 20ft. pitch.

A further interesting development of this machine is the equipment for milling the backs of blades to small steel templates, the latter being capable of cheap and accurate production. The demand on the other capabilities of the machine however precludes the installation and development of this mechanism for the time being.

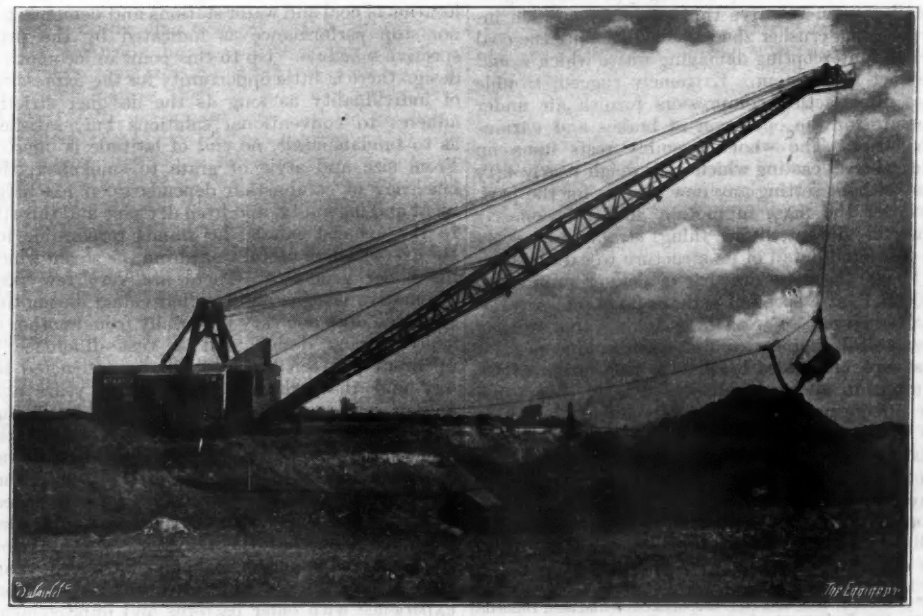


MILLING VARYING PITCH CURVED BLADES

A "Walking" Dragline

THE first of six "walking" draglines to be used for stripping ironstone in England has been installed and is successfully working for the Stanton Ironworks Company, Ltd., in the ironstone quarries of the Wellingboro' Iron Company. This machine is one of two similar machines ordered by the Stanton Company and is a Ruston-Bucyrus-Monighan made by Ruston-Bucyrus, Ltd., of Lincoln. It is, we are informed, the first of its type to be built and installed in Great Britain. This particular machine, which is shown in the accompanying illustration, weighs about 150 tons, is fitted with a 3 cubic yard bucket on a boom 135ft. long, and has been installed to strip and dump about 40ft. of cover. It is electrically driven, and is fitted with Ward Leonard electric control gear.

Another Ruston-Bucyrus-Monighan of the same size, now under construction for the Midland Ironstone Company of Scunthorpe, has an oil engine as the power unit, and is fitted with a boom 155ft. long working in



150-TON 3-CUBIC YARD WALKING DRAGLINE

conjunction with a 2¼ cubic yard bucket to deal with deeper cover than the machine mentioned above.

Although hundreds of this type of dragline excavator are being used in America and other parts of the world it is new to this country, and therefore a short description should be of interest to our readers. A fuller description, illustrated by drawings, of the construction of "walking" draglines appeared in the "Harbours and Docks Plant" supplement to THE ENGINEER of May 19th, 1939.

The main feature of the machine is, of course, the walking device which takes the place of the more usual caterpillar tracks. This device is fitted to the revolving frame and consists of two large steel walking shoes 25ft. long and 4ft. wide, one on each side of the machine, suspended from an elongated cam track. A double-flanged cam or eccentric rotates inside each of the cam tracks. The cams are fitted on squared ends of a large diameter travelling shaft fitted across the revolving frame. The shaft is clutch-operated from heavy gears driven from the main machinery.

The walking action is strong and simple. As each cam is rotated in its cam tracks, driven from the travelling shaft, a crank pin carrying a roller is moved up and down in a vertical slot in the cam frame. The action of the eccentric cam and the vertical motion of the crank pin raises and lowers the shoes and lifts and moves the machine forward when the shoes are pressed on to the ground. A brake holds both shoes in the raised position when the machine is digging; this brake is automatically released when the driving clutch is engaged. Each revolution of the cam carries the machine forward a distance of 6ft. What is usually called the bottom frame of an excavator, is, in this case, a strongly built steel structure 24ft. diameter, and 21in. deep. This circular table rests upon the ground when the machine is digging and swinging. The superstructure revolves on 40 double-flanged rollers 10in. diameter rotating on a swing circle 18ft. diameter. No steering mechanism is required as the machine can travel in whichever position the boom and walking shoes are pointed. The machine can also step and make abrupt turns or travel about the job as required.

The chief advantages of the machine claimed are that the walking device consists of very few wearing parts, all of which are well up out of the mud and dirt; that it gives a very low bearing pressure of 5 to 6 lb. per square inch upon the ground, which is said to be only about one quarter the pressure exerted by a caterpillar-mounted machine of its size; that the centre of gravity is low because of the big circular base sitting directly on the ground; and that a much longer boom can be fitted as compared with a caterpillar-mounted machine of similar weight.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

TRAILING CABLES FOR MINING PURPOSES

(B.S. 708).—The revised specification includes the addition of a section dealing with drill cables as well as some small modifications to the other sections, so that the specification now covers:—(1) Flexible trailing cables for use with coalcutters and similar purposes; (2) pliable armoured trailing cables for use with conveyors, loaders, &c.; and (3) a section dealing with drill cables.

ASBESTOS-CEMENT SLATES, AND CORRUGATED SHEETS

(B.S.S. 690).—A revision of B.S. 690 has just been issued by the British Standards Institution. The first issue of the specification was published in July, 1936, and in the foreword to that issue it was explained that it had not been possible to include requirements relating to the quality of the material, as adequate information as to what tests would be suitable was not available. It was stated, however, that research work was being carried out with a view to evolving suitable performance tests. This research work having been completed, the specification has been revised so as to include the new tests. They comprise a test for water absorption and a test for acid solubility, both of which have been found to be appropriate for testing the quality of the material. Limits for the results to be obtained with these tests are specified and a description of the methods by which the tests are carried out is also given. The opportunity has been taken to increase the figure specified for the transverse breaking strength of corrugated sheets. The foregoing are the essential features of the revision although the opportunity was taken to make some editorial amendments.

ROUND STRAND STEEL WIRE ROPES FOR LIFTS AND HOISTS

(B.S. No. 329).—This revised specification provides for round strand ropes of Lang's or Ordinary Lay of 6 by 12 and fibre, 6 by 19, 6 by 19 Seale, and 6 by 24 constructions, for use with cage or platform hoists or lifts (for passengers or goods) working in guides. It is not intended to apply to ropes for coal hoists or similar lifting appliances. In the revised specification wire below 80 tons to 90 tons per square inch has been eliminated and bend tests on the wires have been included in addition to the torsion tests, and the sizes of ropes are now limited to ropes from ¾in. to 1¾in. circumference. The foreword of the specification has been considerably amplified and modifications have been made to the recommended sizes of drums, sheaves, and diverter pulleys.

The Corrosion of Ship Structures*

By J. H. PATERSON, D.Sc.

Rusting and Corrosion.—The rusting of iron and steel may be defined as the deterioration of these metals due to chemical action on them of the surrounding media—generally air or water, or both. The products of the corrosion of iron are normally two oxides of iron, namely, ferrous hydroxide, which is black or green, and ferric hydroxide, which is red. The mixture of these oxides, known as iron rust, usually contains small quantities of other materials such as carbon, lime, magnesia, silica, and sulphur, when the rust is formed in contaminated air or in impure waters. Modern theories assume that the actuating forces behind the chemical reactions involved are electro-chemical, and that the existence of electrical potential, varying in magnitude with the metal and the surrounding medium, is essential.

In determining how this electrical potential is produced and how the various rusting reactions are maintained, the following facts, the result of test and observation, must be borne in mind: (1) Rust formation requires both water and oxygen; that is, if rusting takes place in air the air must contain at least traces of water, and if the metal is under water the water must contain some oxygen dissolved in it. As all natural waters contain oxygen in solution, rusting will thus invariably take place when the metal is submerged. (2) Rusting is more rapid in acids than in neutral atmospheres or solutions, and is least rapid in alkaline solutions. (3) Films of solid or gas are usually formed on the surface of the metal, and if they are adherent enough they act as a deterrent to further rusting. (4) If the above protective films or any other protecting medium, such as paint, are removed locally by scratching or rubbing, the localised corrosion which takes place will generally be much more rapid than the rate of rusting which would take place if the whole surface were exposed to attack. (5) Local dissimilarities in the composition of iron and steel, or iron in contact with other metals, will set up a local corrosion. Local strains in the iron will also have a similar effect in setting up local corrosion.

Under-Water Rusting and Corrosion.—When a piece of iron is placed in water a minute amount goes into the solution and a similar amount of hydrogen is liberated. This hydrogen forms a closely adhering film on the surface which very soon obstructs the further passage of the iron into the solution to such an extent as to stop the reaction altogether. If rusting is to take place then, this film of hydrogen must be removed not only in the first instance, but all the time the corrosion is taking place. This is done by the oxygen dissolved in the water, and as long as the supply of oxygen is available the hydrogen film will continue to be destroyed and electrical forces will continue to drive iron ions into solution. Some of these iron ions are converted by the water into rust, a part of which will adhere to the metal surface, and a part will float away and be lost altogether.

All sea water contains common salt (sodium chloride) and usually smaller quantities of other chlorides in solution. These salts help greatly in the transfer of the iron particles above referred to, with the result that in salt water these reactions take place more readily than in fresh water.

The Effect of Dissolved Substances.—Some substances, notably acids, tend to increase the supply of hydrogen ions that are available in the water for immediate discharge, in return for iron ions from the metal. Other substances, notably alkaline materials such as soda and potash, have the reverse effect by increasing the number of negative OH ions. The concentration of hydrogen ions is expressed by what is known as the "*p*H value."

Pure water is very slightly dissociated or decomposed into hydrogen ions and hydroxide ions. The product of these two quantities is always a constant in water or in any aqueous solution, and the value of that constant is approximately 10^{-14} at room temperature. Hence, if the concentration of the hydrogen ions is 10^{-4} equivalent per litre, then the concentration of the hydroxide ions is 10^{-10}. The acid properties of solutions are due entirely to hydrogen ions, and the alkaline properties to the hydroxide ions. When these ions are present in equal amounts, the concentration of each is 10^{-7} and the solution is neutral.

This would be the case in pure water. Acid solutions are those which have a concentration of hydrogen ions greater than 10^{-7}. Alkaline solutions are those with hydroxide-ion concentrations greater than 10^{-7}. For convenience, this is expressed as the log of 1/hydrogen-ion concentration, which is given the symbol *p*H. Thus pure neutral water has a *p*H of 7; acids, a *p*H value of less than 7; and alkalies a *p*H of more than 7.

This question of the *p*H value of water is of the greatest importance, as most fitting-out basins are in or near rivers which usually contain dissolved materials foreign to normal water supplies. Sewage, for instance, may at certain stages of its decomposition have a *p*H value of less than 4·5, and it is obvious that if any part of a ship's hull is unprotected, either through scratching or defective painting, it will be the subject of rapid corrosion partly due to the acid water and partly due to the accelerated effects of local exposure. It is interesting to note that in at least one case investigated by the Author the *p*H value of running water in the stream was about 7, whereas the same water on standing for 48 hours developed a *p*H value of somewhere in the neighbourhood of 3·9. This still water effect was produced by the angle at which the ship was lying to the shore, there being on the inner side of the ship an area free from eddies, giving it virtually the effect of a still pool. These readings were taken during an investigation into the abnormal corrosion of rivet heads in the rudder plates of a new ship, and the corrosion was stopped by turning the ship round so that the stern was facing up stream instead of the bow, and bringing the ship more nearly parallel with the jetty so that no places in which water could stand for any length of time were possible.

The occurrence of strong mineral acids in water, such as sulphuric acid and hydrochloric acid, may not be common, but it has occasionally happened that these acids get into the bilges of ships and the effects are worth noting, as, though the local corrosion is of a much more violent nature, it is typical of the ordinary types of corrosion which take place more slowly.

Some members will remember the two ships "Norhilda" and "Querida" which came over in the early part of the last war from the United States carrying strong sulphuric acid in steel drums. A large number of these drums were damaged owing to faulty stowage, and both ships arrived in the Thames with large quantities of free sulphuric acid floating about in them. The fact that this sulphuric acid also contained traces of nitric acid and that it was diluted with salt water made it into a most violent corrosion medium, probably quite without precedent in the history of steel shipbuilding. The bilge pumps on both ships were completely useless, the packings having been eaten out, and the attack on the ships' hulls was so violent that the fizzing noise produced by the escape of hydrogen could be heard at almost any part of the ship. Owing to the promptitude with which the trouble was dealt with both ships were saved without serious damage, except that where the acid had been practically all the rivet heads were eaten away. Here and there the edges of the angle bars had been attacked, and in some parts of the structure that had been subjected to cold bending there were signs of pitting along the parts which had been strained during the bending. Both ships, however, were completely reconditioned without difficulty.

Localised Corrosion.—If two dissimilar metals such as iron and copper are placed in contact with one another under a conducting solution such as impure or salt water, a small electrolytic cell or battery will be formed, the system being equivalent to passing an electric current through the solution by connecting the iron or more negative element with the positive pole of the battery and the copper with the negative pole of the battery. As soon as current begins to flow the *p*H value of the layer of water over the iron falls to a low figure and comes well within the area on the *p*H curve in which rapid attack will take place. The result is that the iron is dissolved, and if the solution contains salt, as is the case with sea water, a soluble iron chloride will be formed which will float away and leave a clean unprotected surface always ready for a fresh attack. This is what is known as "electrolytic corrosion," and it is in one way or the other largely responsible for a great deal of the pitting that occurs in ships' plates. Instead of copper any material that is more electro-positive than iron will have exactly the same effect. Among these materials unfortunately mill scale or magnetic iron oxide must take its place. Although mill scale is not a metal it acts like a metal that is more electro-positive than iron, and where a particle of mill scale is in close contact with iron and has free access to sea water a small area over the iron will be formed with a low *p*H value and with a resulting rapid attack. A completely adherent coating of mill scale would be an effective protector, but unfortunately it is a brittle material which is easily broken up by shock or by bending, and obviously imperfect coverings of this substance are much more dangerous than a surface perfectly free from the scale. The only known remedy for this trouble is the complete removal of the scale by pickling or sand-blasting, although, of course, ordinary weathering conditions do remove a large bulk of it.

A variation in the composition of iron or steel within the same body of the metal can set up differences of potential when it is immersed in water. Thus it has been found that in a badly segregated steel, that is, one in which the carbon content is not evenly distributed throughout the metal, the higher carbon areas will be anodic to the lower carbon areas. This means that over the higher carbon areas the water solution will have a lower *p*H value, and hence corrosion will take place more rapidly at these points. This has been well exemplified in the case of the well-known corrosive attack on the points of rivets made from rimmed steel.

It has also been shown that steel which has been subjected to stress and is in a condition of strain, is anodic to less strained steel alongside it. This means that plates which have been subjected to cold bending and are under water in an unprotected condition are liable to have an area of low *p*H value along the lines

* Extracted from a paper read before the Institution of Engineers and Shipbuilders in Scotland.

of maximum strain. Similarly, rivets which have been closed at a low enough temperature to retain strain will be anodic to the plates surrounding them, and will also be the centres of areas of low *p*H value. Although it is not fully proved, it appears quite certain that the higher the carbon content of the steel and therefore the greater the strain it retains under cold working conditions, the greater will be the difference in potential between the strained and unstrained portions. This means that in a badly segregated steel that has been subjected to cold working there may be differences of potential between the areas having different compositions, in addition to the potential differences set up by these composition differences. When it is remembered that if this is true mild steel plates which have been sheared, punched, cold bent, or hammered have areas of potential corrosion at these points, it is not surprising that wrought iron plates which have undergone similar treatment do not show anything like the same deterioration due to local corrosion in service.

Notch Corrosion.—It has been pointed out that oxygen is a necessity for the rusting of iron and steel when under water, and it has been assumed all along that the concentration of oxygen in solution in the water has been quite constant over the surfaces in contact, so that the rates of corrosion are fairly uniform. It was found some years ago, however, that if for any reason the oxygen concentration in the solution varied in different places, a difference of potential was set up in the steel between the high concentration spots and the low concentration spots. Dr. U. R. Evans in a series of experiments on oxygen in solution showed that areas which are shielded from oxygen in any way become anodic to the areas which are in contact with solutions richer in oxygen. If this is so, then obviously these anodic areas will be, under suitable conditions, the subject of more or less rapid corrosive attack. Suppose that a small cavity exists in the surface of the metal into which oxygen cannot diffuse quickly. A current will be produced between the unaerated area within the cavity, which will become anodic, and the aerated part of the surface outside, which will be the cathode; soluble salt will be formed at the anodic surface within the cavity, but this will not interfere with further anodic attack. At the mouth of the cavity where the soluble metallic salt from the interior mixes with the alkali from the cathodic part outside hydroxide may be precipitated, but it will not put a stop to the anodic attack proceeding within. Since the rate of attack is determined by the supply of oxygen to the whole surface outside the pit, and since it is all concentrated on the small area within the pit, the rate at which the corrosion bores into the metal will be very great.

A notch, of course, may be almost any part of a structure into which the surrounding water cannot penetrate quickly and in which it remains perfectly still. Very imperfectly caulked laps between plates are a good example and improperly filled junctions between plates and angle bars are another. Under these conditions local corrosion will take place in these partly closed areas and at a much greater rate than would be the case on a fully exposed surface.

Stray Electric Currents.—A great deal has been written about the effect of electric current leakages on the corrosion of iron and steel structures when in contact with water or moist earth. Leakage usually occurs by the passage of current from a badly insulated conductor at a high potential to one at a lower potential, and if these two conductors are under water it will be obvious that an electric cell is formed, and the conductor, which is acting as the positive pole or anode, will be the subject of rapid corrosion in a medium such as salt water. Those parts of a ship's hull, for instance, which, owing to the existence of launching structures, such as the forepoppets, get no paint or only the merest dab, have been on several occasions found to be corroded after only a few days in the water. There is no doubt that in such instances electrolytic corrosion, due to stray currents, is to be suspected, and indeed has been known to happen. On the other hand, in numerous instances where corrosion of a more or less serious nature has taken place it has, without any adequate reason, been put down to the action of stray currents, and the whole matter requires a great deal more consideration than has been given to it.

Protective Media.—It will be recognised that in view of the large number of possible causes for the production of the right corrosive conditions, protective media are in the end the only satisfactory solution of the whole problem. There is, however, still a good deal of controversy as to the way in which these media should act, and there are no settled convictions as to the superiority of one method over another. Obviously galvanising of steelwork is an enormous help in the right direction. Zinc not only forms a protective coating over steel, but where breakage occurs on the zinc surface it still acts as a protective medium and prevents the corrosion of the exposed steel surface. For ordinary purposes, however, this is much too expensive and we still have to rely on liquid mixtures such as paints and bitumen solutions. The only points that can be brought out here are: (1) Any protective medium must be impervious to moisture and to oxygen as otherwise rusting can take place under the protective coat. (2) The solid fillers contained in most protective media must not be capable of attack from any external source, as otherwise the continuity of the protective surface may be destroyed and corrosion will go on as though the medium were not present. It has been found on several occasions, for instance, that when lime compounds have been used as fillers in tank top compositions, liquid condensates from the cargo or from the coal bunkers have been slightly acid in character, and the composition has gradually deteriorated and allowed corrosion to take place underneath it.

American Engineering News

Multiple-Purpose Hydraulic Projects

Modern development in hydraulic engineering projects were reviewed in an address by the head of the United States Bureau of Reclamation. He pointed out that until a comparatively recent period, an irrigation dam was designed with no other object beyond irrigation, and the same applied to works for navigation, flood prevention, and power development. Yet almost every reservoir formed by a dam would serve other purposes more or less effectively. At a flood prevention dam, the flood water held must be released at times of low flow, and would thus affect other activities on the stream below. And a dam built for a power plant might readily be utilised to serve other purposes. In the multi-purpose project, a little expansion in the planning stage would enable it to serve not only its main purpose but other related functions of importance. In the arid and semi-arid regions, it is found easy to combine flood reduction with irrigation storage. The reservoir on the Tygart River, designed primarily for aiding navigation, is used also for flood control, and the reservoir intended for low-water control on the Shenango River has proved effective in providing an adequate supply of water for manufacturing purposes during low-water periods and also in holding back flood waters which might have been disastrous. While such reservoirs operated for several purposes cannot be 100 per cent. effective for all these purposes, the aggregate benefit to the community can be made much greater than would be possible if the reservoirs were operated for only a single purpose. Hydraulic works now under way for the Central Valley development in California will serve a variety of purposes:—improved navigation, reduction in flood damage to irrigated lands, irrigation of a million acres, production of low-cost power, and regulation of river flow for domestic supply and industrial uses.

Lighting Highway Tunnels

With the increasing use of tunnels on American highway routes, for both normal and high-speed traffic, their effective lighting becomes important, both for the comfort and convenience of drivers and for the general safety of traffic. Many earlier installations have only low illumination rates, from 0·5 to 1 foot-candle-power, together with an irregular distribution of light. More recent installations give an average illumination of 2·5 to 4 foot-candles over the entire width of roadway, while an illumination of 5 to 7 foot-candles has been planned. These modern systems employ incandescent lights at 20 to 30ft. centres and 14ft. above the roadway. Larger sodium lights are spaced 30 to 40ft. at the same height, or 50 to 60ft. in tunnels where an arched roof gives 20 to 22ft. headroom. The Stockton Street tunnel, in San Francisco, has lamps of the enclosed type, with sodium lamps of 10,000 lumens 30ft. apart, but at a height of only 13ft. In another case, similar lamps are 50ft. apart over the centre of the roadway. The Salt Creek tunnel has 10,000-lumen lights set in recesses in the ceiling at 21ft. height and 40ft. apart. At tunnel entrances, graduated illumination in a length of 200 to 300ft. minimises the momentary loss of visibility in changing from daylight to artificial illumination. Incandescent lamps in large sizes, or a combination of mercury and incandescent lamps may be used for such situations. Sodium lamps are proving more efficient than incandescent lamps for tunnel lighting, as their output is 55 lumens per watt, as compared with 15 to 20 lumens for the latter, while the life of sodium lamps is from 6000 to 10,000 hours of continuous lighting. There is little information as to the life of mercury and fluorescent lamps in continuously-burning circuits. The 10,000-lumen alternating-current sodium lamps may be operated from either a 6·6-ampere constant-current series circuit or from a multiple circuit.

American Coffee-Roasting Plant

With the enormous consumption of coffee in the United States, there are extensive developments in modern methods of handling and processing the raw material for the various commercial brands. A new plant completed recently in New York harbour has elaborate equipment for handling, mixing, blending, roasting, grinding, and packing 300 tons daily, and has also a plant for the manufacture of its own cans. For the steamers which bring green coffee from Central and South America there is a pier 600ft. long and 60ft. wide, having wood piles cut off 12in. below water level and carrying a heavy flank deck. Around this deck is a concrete retaining wall which carries the steel columns of the cargo shed and retains a solid filling of cinders, compacted by rolling and covered with a concrete floor. A wharf provides for barges. Most of the buildings are of steel frame construction, with exterior walls of concrete, brick, or corrugated asbestos-cement sheeting. The pier shed and storage warehouse provide for the storage of 7000 tons of green coffee in sacks. For the building with heavy machinery for the manufacturing operations concrete frame construction is used, including a six-storey processing building and a four-storey can factory, in both of which the operations are arranged for gravity flow. In the processing building, coffee from storage is fed to the basement, and thence elevated to the roof level, from which it flows successively through the cleaning, blending, roasting, grinding, and packing departments, the filled cans then being delivered at the first or ground floor, which has tracks for railway cars on one side, and a driveway for motor trucks on the other side. For facility of loading, the outer columns are set back 8ft. from the walls, the upper floors being cantilevered out for 8ft. Floor loads range from 250lb. to 2000lb. per square foot, and a special feature was the design of floors for innumerable ceiling inserts for the attachment of machinery parts.

Timber in Structural Construction

With so much development in steel and concrete as used in structural work, it is probable that many engineers do not realise the parallel developments in the use of timber for important structures in the United States. There are vast forest resources of timbers of excellent quality for the purpose, and many government and private organisations are studying the qualities and characteristics of such timbers and the economic aspects of design in timber structures. One of the fundamental results of such research is the formulation of commercial grades of timber as to species, strength, and durability; and the standardisation of sizes, shapes, and lengths of timbers for structural use. In recent years there has been a radical improvement by the use of metal connectors to fasten timbers together, supplementing the ordinary bolted connections. Another innovation is the use of fibre-board or veneers as gusset plates in timber trusses for roofs and bridges. With veneers glued together and having the grain running in opposite directions in the several sheets, the strength and stiffness of the finished plates is very high. Treatment for preservation is very general, and much economy results from having the several pieces cut, shaped, and bored before treatment. Besides short-span bridges of the trestle type, with numerous spans and sometimes considerable height, timber is being used extensively for railway and highway truss bridges. Typical structures include a floating dry dock 126ft. by 450ft.; lattice and Warren type trusses for bridges of 100ft. span; a wireless tower 166ft. high, of triangular section; and parallel-chord arch trusses of 125ft. span and 44ft. rise. Laminated construction, with the use of layers of plank, has been used in truss and other designs; as well as columns built up of planks in place of solid one-piece-posts or columns. Special consideration is being given to the design of joints and timbers put together by the use of nails, bolts, and "connectors."

Beach and Shore Protection Works

During 1939, the United States Beach Erosion Board completed a survey and study of conditions at the Hawks Nest beach, and started four more specific studies in addition to those already in progress. The beach named is a low and narrow sand barrier, with salt marshes on the land side. In 1938, a hurricane struck and destroyed all developments, only a few of 100 shore-front summer cottages escaping. A characteristic of storm tides which is especially significant in the case of narrow barrier beaches is that the on-shore storm winds increase the normal height of high water, so that the vertical zone of wave attack is much greater than would be indicated by the normal range of tide. In this particular case, the storm which inundated the beach and destroyed the buildings did comparatively little damage to the beach, since the storm waves broke at the level of ordinary high water and the inundation due to the high storm tide protected the beach from such excessive erosion as might have occurred if the waves had plunged in the range of ordinary high tides. Protection against hurricanes and storm tides by sea-walls, with ground filled in behind them is too costly for general use; though the cost is justified where the population is dense and property value is high. But the report emphasises that in all such cases of shore-front development and occupation it is essential to provide paved highways of approach at such elevation as to insure safe evacuation of the people in the event of hurricane attack. The Board has prepared a "Manual" for beach erosion studies, explaining the various government regulations and outlining the field and office work of such surveys. Both field and laboratory studies are being made of shape, velocity, orbital movement, and height-length ratio of waves; together with the movement of the bottom material, and the changes in waves which pass into gradually or rapidly shoaling water. Engineering colleges and their experiment stations are expected to assist in this line of research.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

Continental Steel Market

Up to the present it is difficult to estimate to what extent trade in Continental steel will be affected by the German invasion. Immediately prior to the latest crisis the works were finding export business difficult, not only as American competition is met with in the most unexpected countries, but because the volume of inquiry is diminishing. It is suggested that the invasion of Denmark and Norway has disturbed the confidence of foreign buyers in the European trade situation and that they are holding aloof. The Scandinavian markets had been amongst the Belgian steelworks' best customers for some months, and their loss will be severely felt. Telegraphic communication between Belgium and Denmark still exists and instructions have been given to the Belgian steelworks that the considerable tonnage of orders for that country now on their books must be proceeded with. Up to date, however, no indication has been given as to the way in which these steel materials will be delivered. New business with overseas countries has been poor; but several of the steelmakers have been declining orders as they have so much work in hand. The home market is exceptionally active, however, and the demand for steel for rearmament combined with the tonnages taken by Great Britain leave little margin for other business. In the case of some works deliveries are from four to five months in arrears. Lately the Belgian and Luxemburg steelmakers have transacted a fair amount of business with Holland and Switzerland, but it is difficult to see how the Belgian steelworks can do without their export trade. There is no doubt that the Belgians are worried by the extent of the business taken by American steelmakers at prices well below the Continental rates. Recently, however, American quotations are reported to have been increased for South American countries and a transaction is reported in bars at $8 above recent levels. This makes the price about Frs. 1750 c.i.f. Buenos Aires, which is not much below the Belgian quotation. The Belgian steelmakers, however, take the view that when their works are operating under more normal conditions they will be able to recapture the markets which they have temporarily lost. The figures published by Coisbel, the Belgian steelworks' selling organisation, give the tonnage booked in the first sixteen days of April as 151,000 tons, which was nearly all for the Belgian home market and England and France. In France the steelworks are working at capacity. The recent decree of the Government will prevent any increases in commodity prices including iron and steel for the next three months and it is thought that probably some dissatisfaction will be expressed as the costs of production have risen materially. New prices, however, have been permitted for cold rolled hoops and some descriptions of tool steels.

The Pig Iron Market

Pressure to obtain supplies of pig iron is increasing and the expansion in the demand is particularly noticeable in the basic iron department. With the steelworks operating at capacity and all available plant put into operation large supplies are needed. In normal times the production of basic iron by the plants associated with the steelworks is fully consumed by the big integrated concerns, and the output for what is known as the "free market" does not suffice to meet requirements in times of pressure. As a result there is a large importation annually, and in wartime this is considerably increased. Of course, there is no "free market" to-day as the Control is responsible for the distribution of the production. A few months ago the position gave rise to some concern amongst the steelmakers, but during recent weeks there have been large arrivals of basic pig iron in this country and the Control appears to have the situation in hand. On the North-East coast the production of Cleveland foundry iron has been practically suspended for many months, and it is not expected that it will be resumed during the war. The makers are concentrating upon the production of basic iron and hematite for the steelworks and outputs have attained high levels. Founders who formerly relied upon Cleveland iron have become accustomed to the use of Midland irons, considerable supplies of which now reach the North-Eastern district. In fact, it has been suggested that the manufacture of Cleveland iron will never be resumed, at least, not upon the former scale. The demand for all foundry irons appears to be slowly expanding, but it would have to increase much more than seems possible before the situation can become stringent. The chief reason for the comparatively quiet demand for foundry is the slack working of the light castings foundries owing to the limited activity of the building trades, which normally absorb the greater part of the output of these works. Even in the case of foundry iron the quietness is restricted to the high phosphoric grades as the engineering trades and the motor vehicle manufacturers are large consumers of low phosphoric descriptions. In fact, there is some scarcity of the latter grades and it is expected that an effort will be made to increase the production. Business in foundry irons in Scotland is not active and stocks are reported to have accumulated at some furnaces. This again is chiefly due to the poor conditions at the light castings foundries. In Lancashire there is a brisk request for low phosphoric irons and the engineering concerns find it difficult to obtain their full requirements. Large tonnages of hematite are being produced and passing into consumption at the steelworks. Considerable deliveries are being taken up in the Sheffield district. Although there is no shortage of this iron the production is not more than sufficient to meet consumers' needs.

Scotland and the North

The heavy steelworks in Scotland are maintaining the high rate of production of recent weeks. Supplies of ore have been reaching them at a steady rate and the scrap position although tight is better than it was earlier in the year. The demand, however, more than keeps pace with output and there are indications that in some departments of the war effort production has been speeded up so that the pressure upon the steelworks is increasing. It is clear that, notwithstanding all the efforts of the steelmakers to meet consumers' requirements, they are being gradually left behind in the race and that orders are accumulating. The introduction of the distribution scheme should provide some relief, but so heavy are the order books of the steelworks that it will be some months, probably, before the full benefit of this plan can be seen. The big Admiralty programme of naval and merchant vessels initiated a few weeks ago requires even at this comparatively early stage huge tonnages of steel. Great quantities of structural shapes are moving to the shipyards and there is an incessant demand for plates of all thicknesses, although orders for the heavy and medium sizes predominate. The Scottish constructional engineers are probably busier than ever before. Numerous extensions to works are in hand, and at the same time a large Government programme in connection with the building of munitions establishments and other erections concerned with the war effort require almost unprecedented tonnages of steel. The re-rolling works are operating full time and their position so far as raw materials are concerned has been greatly improved by the distribution of imported semis. In addition to heavy tonnages of small sections they are producing considerable quantities of strip, including tube strip. The malleable ironworks which for a long time were not receiving many war contracts have for the last few weeks benefitted by the diversion of orders from the steelworks owing to the earlier delivery they can offer. The Lancashire market remains active and there is a considerable volume of inquiry which consumers find it difficult to place. The general engineers in the Lancashire district are without exception fully employed and their requirements of ordinary steel, as well as of special and alloy steels, make up a heavy tonnage. The collieries are absorbing large quantities of steel in the shape of arches and roofing bars, and the demand in this industry appears to be steadily increasing in spite of the active conditions which have ruled for some months. The wire drawers in Lancashire are working at capacity and are taking up large tonnage of semi-finished materials.

North-East Coast and Yorkshire

The high rate of production by the steelworks on the North-East Coast has been fully maintained, and it is probable that when statistics are again published some interesting figures of the war effort by the local steelmakers will be disclosed. The works have been engaged in working out details of the new distribution plan and it seems possible that this will be in full working order at an earlier date than was at first thought possible. All the works have an enormous tonnage of orders in hand and except in cases of national urgency it is difficult for consumers to place new orders. The works producing semi-finished steel have been operating at capacity for months and have gradually fallen behind under the pressure of the intense demand. Lately large supplies of semis have reached this country from Belgium, and it is suggested that supplies originally destined for Norway, Denmark and other Scandinavian countries may now be diverted to Great Britain. This, however, is not certain since there is little doubt that consumers in these countries will exhaust every effort to secure deliveries of steel materials, including semis. The re-rolling industry, however, has benefitted from the larger supplies which have reached them and some impression is being made upon the arrears of orders which had accumulated. The heavy steelworks are still working under great pressure and have many weeks' employment in hand. New business is not easy to place, and it seems probable that the production for the first period under the new distribution scheme will be principally devoted to working off existing contracts, although essential work will naturally have to be executed. The shipyards on the North-East Coast continue to absorb large quantities of steel and there is little likelihood of there being any relaxation in this demand. The constructional engineers are busy upon numerous contracts, many of them for the Government and some of considerable importance. Their requirements of joists and sections have reached phenomenal figures and are likely to increase rather than diminish as the year progresses. It is reported, however, that foreign purchases will be made of structural steel in order to ease the position in this country. The sheet makers are working full time and most of their production is for purposes directly or indirectly connected with the war. The makers have received considerable inquiry on export account, but their engagements for home consumers prevent the acceptance of more than a small proportion of the business offered from overseas. The Yorkshire steelworks are equally busy and the Sheffield steelmakers in particular have a large accumulation of orders in hand. Basic steel is being produced in large tonnages and there is an active demand for acid carbon billets. The production of special and tool steels is gradually expanding and a valuable trade is passing in steel for use in aircraft manufacture.

Copper and Tin

The copper situation in Great Britain gives rise to no anxiety and in fact it may be regarded as comfortable. Supplies coming in from Empire sources are arriving with regularity and the Control is able to carry out the distribution of the metal to the satisfaction of the consuming industries. Practically all the latter are engaged upon Government contracts, and although their requirements are exceptionally large there have been no complainst that the requisite quantities of metal have not been available. The world market ruled weak during the last half of April and at the moment there seems no reason to expect a revival of activity. The quotation in the United States has receded to 11·25c. f.a.s., but this has failed to stimulate any buying on the part of neutrals. The only countries showing an interest have been Italy and Russia, but the former does not appear to have bought extensively and the latter has been unable to purchase the quantities required. The official American export figures for March, however, showed that Italy was the largest buyer in that month with a total of 6506 (short) tons, Russia coming next with 4986 tons. Great Britain received 2900 tons, Japan 3521 tons, whilst France took 2427 tons. An interesting comment upon conditions in the United States was made recently by Mr. C. D. Dallas, President of the Revere Copper and Brass Incorporated. He said that domestic business was in fair volume, and added "only the most daring would venture upon an expansion of plant or production at this time, and they are prevented from taking this risk by the certainty of high confiscatory taxes if they are eventually successful." . . . The tin market has been steady and conditions do not show much change. The Statistical Bulletin of the International Tin Research and Development Council states that the world production in the first quarter of 1940 totalled 52,600 tons compared with 72,500 tons in the preceding quarter. Exports from the countries signatory to the International Tin Control are estimated at 46,453 tons during the first three months of 1940. In this period the deliveries to the principal smelters amounted to 52,632 tons, against 53,100 tons in the previous quarter. The apparent world consumption was 62,400 tons compared with 53,000 tons in the last quarter of 1939. The total apparent consumption in the United States in the quarter under review amounted to 25,000 tons, leaving 37,000 tons for other countries. The market has had a rather healthy appearance, but no development of particular interest has occurred. The backwardation persists, although it is considered that the tightness in the spot position from which it arises is largely artificial in character. American buying has been spasmodic and not very active. It is, in fact, considered that American consumers have covered their requirements to such an extent that they are not likely to enter the market for some time.

Lead and Spelter

There is no alteration in the lead market in Great Britain. Supplies up to the present have been coming forward regularly and so far the diversion of British shipping from the Mediterranean does not appear to have had any adverse influence upon the situation. The consuming industries are almost without exception fully employed upon war work. There is no doubt that heavy tonnages are being taken up; but in the absence of statistics only a general estimate can be formed of the situation. Although there has been a certain amount of talk of the manufacturers of lead products entering the export market, and of the importation of foreign lead apart from the metal which is being received by the Control from Empire sources, it is doubtful if there is enough plant available to make this a worth while project. Naturally the Control has to play for safety, and its reluctance to issue licences for ordinary commercial purposes or even for the export of manufactured materials is understandable. The Metal Exchange contracts which were uncompleted on the commencement of the war have now been liquidated and all the lead in dealers' hands available for sale has been disposed of to consumers. . . . Satisfactory conditions continue to rule in the spelter market. Large quantities are reaching Great Britain from Empire countries and it is understood that these are passing at once into consumption. This indicates the important place occupied by spelter amongst war metals. Supplies, however, appear adequate, even for the war needs of the country, and should more be required there would be no difficulty in increasing the quantities imported. Commercial users are understood to have difficulty in obtaining the tonnages they ask for, but this is to be expected since the Control has to keep a certain amount of metal in hand to guard against any possible interruption to supplies. Although the contracts for galvanised sheets for the manufacture of air raid shelters have been practically completed the Government's requirements of this material continue large and there has been no relaxation in the demand for spelter from the galvanising industry. Another industry which continues to absorb important tonnages is the brass trade and it is likely that the requirements in this direction will not materially decline during the war.

Imports of Chromium Compounds

Under the Import of Goods (Prohibition (No. 18) Order, 1940, chromium compounds have been added to the classes of goods which may be imported only under licence issued by the Board of Trade. The Order covers not only such compounds as chromium acetate, chromium sulphate, chromic acid and chrome mordants, &c., but also such substances as chromates and bichromates. The Order will come into force on May 10, 1940, but goods of the kinds covered by the Order which are proved to the satisfaction of the Customs authorities to have been despatched to Great Britain before that date will not require a licence. Importers are warned that they should not arrange for any other goods covered by the Order to be sent forward to this country until they have obtained a licence. Applications for licences should be addressed to the Import Licensing Department, 25, Southampton Buildings, Chancery Lane, London, W.C.2. Forms on which the applications should be made are obtainable from the Import Licensing Department or from the Offices of H.M. Collectors of Customs and Excise.

UPPER MISSISSIPPI RIVER IMPROVEMENTS.—The canalisation work on the Upper Mississippi River was completed in March, and the channel depth from the mouth of the Missouri to Minneapolis, a distance of 658 miles, is now controlled by a series of 26 dams and locks. This work has cost about 170 million dollars.

French Engineering Notes

(From our own Correspondent in Paris)

Anglo-French Trade

THE close collaboration of Great Britain and France in developing their trade and economic resources implies understanding on so many questions of detail that it may be some time before the co-operation plan can work with complete smoothness. As matters now stand, imported goods are divided into classes A and B, the former covering practically all goods and products in which trade can be done with the British Empire. In this class the prohibition of imports, except under licence, is replaced by a system of quotas, based upon the volume of imports before the war, sufficiently elastic to allow of their being exceeded so long as there is no abnormal importation prejudicial to the country's gold reserve. Licences have therefore still to be obtained through the medium of syndicates representing various groups of industries. There are the Syndicat des Industries de la Mécanique, the Fédération Syndicale de Machinisme Agricole and others which combine the interests of everyone concerned in them. Applications to the Ministry of Armaments for import licences are transmitted to these syndicates, which base their acceptance or refusal upon the one consideration of whether the goods to be imported can be manufactured in France. This rigid method of preventing imports of manufactured goods has proved effective, except in cases where machines and other goods are required for national defence. Its operations do not appear to have been adapted sufficiently to a new situation created by the agreement to provide facilities for trade with Great Britain. This is the complaint of importers of British goods. Some of them have been surprised at the facility with which goods have come through, but others are not so fortunate, and their demands for licences meet with objections which show that some manufacturing interests are not yet fully alive to the importance of the national interest involved in carrying out the Anglo-French agreement. Particular interests continue to dominate partial discussions on this national question, and it is for this reason that more frequent contacts between British and French industrialists would be of value in conciliating divergent views on matters of detail and in smoothing out difficulties that really ought not to arise. When there is something like unanimity with regard to questions of detail the Government and the Confédération Générale du Patronat, which may be regarded as initiators of the trade co-operation, will find it easy to complete their task.

An Oil Find

In its exhaustive survey of possible home mineral oil supplies the Office National des Combustibles Liquides settled upon a region in the south of France as offering the most promising chance of finding oil that could be exploited commercially. It covers parts of the departments of Haute-Garonne, Hautes-Pyrenées, Ariège and Gers. Boring began near the town of Saint-Gaudens in the Haute-Garonne in June of last year, and a month later there was a blow of gas which, for some unexplained reason, provoked an explosion. Another bore was made which went through oil at 1200 m., 1500 m. and 1800 m., but it had been estimated that the principal layer would be at a depth of between 2500 m. and 2800 m., and it was struck at 2300 m. As the work was continued during the war nothing was heard of it until an official announcement was made recently to the effect that in the latter half of April tests were being carried out at the bore and showed that the oil was under the high pressure of 100 kilos. per square centimetre. Its quality was declared to be particularly good, with 22 per cent. of pure petrol. During the few hours that the test lasted, 10,000 litres of oil passed through the valve. The official description of a "probable rich and extensive oil deposit" appears to be justified by reasonable deductions. Two other bores are being sunk near the site of the first one, and prospecting is carried on over an area which is now clearly defined. It is supposed that the oil deposit extends from Castelnau-Magnqac, in the Hautes-Pyrenées, to Salies-du-Salat, in the Haute-Garonne, and ends in the department of Ariège. At Castelnau-Magnqac there are abundant evidences of methane and propane gases and at Salies-du-Salat salt mines exist, so that, with favourable geological data, there are normal indications of a large oil supply. The supposed oil bearing zone lies within the area over which the State reserved exclusive rights when oil was first struck at Saint-Gaudens on the ground that the whole of the prospecting work had been done by the State Office National des Combustibles Liquides, of which Monsieur Pineau is director. The area is enclosed in a triangle, the base of which extends from the Ariège through Saint-Gaudens to Lannemezan, in the Hautes-Pyrenées, and the perpendicular to Mirande, in the Gers. The only other oil production in France is at Pechelbronn, in Alsace.

Public Road Haulage

The difficulties arising out of restrictions on public road haulage on the outbreak of war have now been removed by decree which gives more liberty to owners of light and heavy lorries. At first, all long-distance transport was practically suppressed and severe limitations were imposed on the use of lorries within departments, the object being to economise petrol and leave all long-distance traffic to the railways. The experiment failed through wagons and trucks being held up at station sidings and terminals, thereby limiting the carrying capacity of rolling stock. It was therefore decided that more use must be made of the roads for the benefit of railways. As a means of relieving the railways of congestion due to the accumulation of wagons and trucks that wait to be loaded and unloaded almost complete liberty is now given to road hauliers within departments, so that they may facilitate this work by a more rapid distribution. Long-distance road haulage is limited on the ground that if the same liberty were permitted, owners of lorries would desert the departments where they are most needed for the more profitable work. On the other hand, full liberty is allowed for lorries running on charcoal, suction gas or other national fuels.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES

519,116. September 15th, 1938.—IMPROVEMENTS IN THE CYLINDER BORES OF INTERNAL COMBUSTION ENGINES, ESPECIALLY SLEEVE VALVE ENGINES, D. Napier and Son, Ltd., and Henry Christopher Tryon, both of 211, Acton Vale, London, W.3.

This invention relates to internal combustion engines and more particularly to the cylinders or sleeve valves within which the pistons operate. It has been found that in some instances oil on the wall of the cylinder, passing by the scraper rings and reaching the combustion space results in excessive oil consumption. To prevent this it has been customary to provide holes through the piston placing the scraper ring groove in communication with the interior of the piston. In some instances, however, more especially in the case of engines having horizontal cylinders, this has not always been found satisfactory. The invention is applicable to internal combustion engines having vertical, horizontal or inclined cylinders. In the construction illustrated the engine comprises a water-cooled cylinder A having inlet and exhaust ports, one of which is shown at B, controlled by a sleeve valve C. Arranged to reciprocate within the bore of the sleeve valve is a piston D having two

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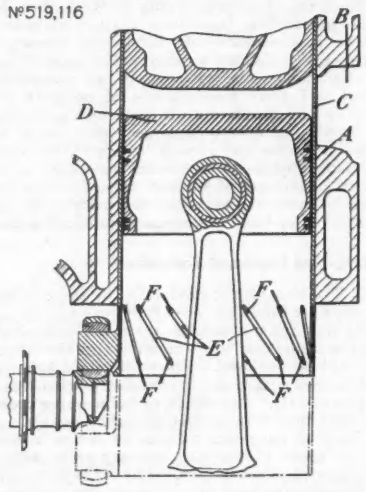

pressure sealing rings and two scraper rings. Formed in the bore of the sleeve valve C adjacent to its lower end is a series of inclined grooves E, the inclination of these grooves being approximately 45 deg. to the cylinder axis and their disposition being such that at the lowest position of the piston relatively to the sleeve the scraper rings lie adjacent to or below the lower ends of the grooves while the pressure sealing rings lie above the grooves. The upper end of each groove overlaps in a circumferential direction the lower end of the adjacent groove and each groove is provided adjacent to its ends with holes F which pass through the wall of the sleeve into the crank case. The motion of the sleeve is such in relation to the disposition of the grooves that during the initial part of its movement the rotational movement is such that the upper end of each groove lies circumferentially in advance of the lower end of the groove. Rotational motion in this direction continues throughout approximately half the downward movement of the sleeve, with the result that the grooves tend to have a pumping action, so to speak scraping oil from the surface of the piston and drawing this oil downwards and delivering it through the holes directly from the grooves into the crank case.—*March 18th*, 1940.

DYNAMOS AND MOTORS

518,891. September 7th, 1938.—ALTERNATING ELECTRIC CURRENT GENERATORS, Joseph Lucas, Ltd., of Great King Street, Birmingham, 19, and Ernest Ansley Watson, the same address.

This invention has for its object to provide an improved

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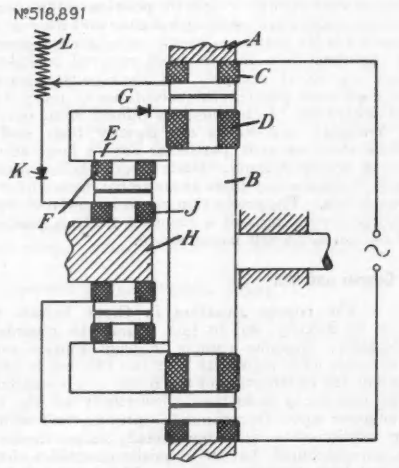

dynamo for generating alternating electric currents. In carrying the invention into effect A is the main stator and B the rotor. The stator carries the generating windings C, and the rotor the field windings D. The exciter comprises a rotor E connected to or constructed integrally with the main rotor B and provided with generating windings F. These windings are connected to the field windings D of the main rotor through a rectifier G. The stator H of the exciter is surrounded by the rotor E and is provided with field windings J. The latter may be supplied with direct current from any convenient source, but preferably they are supplied from the generating windings C of the main stator A through rectifier K. An adjustable resistance L is provided for varying the current supplied to the exciter field windings J. This resistance L may be automatically controlled by the dynamo output voltage for the purpose of maintaining the latter constant under variable load. Instead of employing the resistance L, provision may be made for periodically interrupting the circuit of the exciter field windings or for short circuiting these windings, under the control of the dynamo output voltage. The invention is especially suited for small dynamos required to generate alternating currents.—*March 11th*, 1940.

MISCELLANEOUS

518,897. September 7th, 1938.—DEVICES FOR INDICATING THE RATE OF FLOW OF AIR OR OTHER GASES, Westinghouse Brake and Signal Company, Ltd., and Alexander Jenkins, both of 82, York Way, King's Cross, London, N.1.

The device is partly contained in a casing which is completely closed except for a slot in the wall A forming the conduit or passage for the stream of fluid, the rate of flow of which is to be indicated, The device comprises a rectangular vane B projecting through the slot, the end within the casing being rigidly secured to the upper face of a rectangular metal block C which is capable of rotation through a small angle (approximately 15 deg.) about a horizontal axis. Projecting from the face of the block is a screw-threaded rod D carrying a counter-weight in the form of a nut. The centre of gravity of the vane, its attached block and counter-weight is slightly above the axis of rotation, and by rotating the nut the centre of gravity of the moving system can be adjusted so that the unbalanced weight causes the vane to occupy its position of rest as shown in full lines, in engagement with the lower edge of the slot in the casing. Projecting from the block is a contact operating arm, in the form

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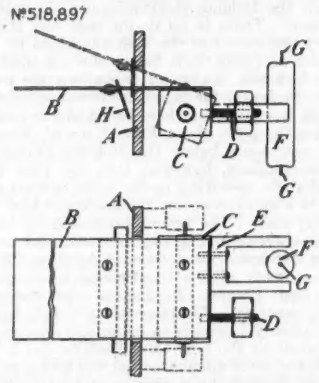

of a horse-shoe permanent magnet E, the projecting arms of which are arranged to displace a magnetic armature contained in a fixed insulating tube F containing mercury, the level of which is varied as the armature is displaced following the movement of the magnet. The mercury is thereby caused to engage with contacts G sealed into the tube. The contacts are connected in the operating circuit of an electrically actuated indication device. The vane adjacent to the exterior of the casing and to the slot has a projecting plate H, which, when the vane is in its operated or deflected position shown in dotted lines covers the slot, thus preventing the entrance of dust into the casing. In operation, the vane is maintained in its position of rest so long as the speed of flow of the stream of fluid is below a critical value, determined by the adjustment of the counter-weight. Under these conditions the vane rests, as shown, against the lower edge of the slot, but as soon as the critical speed of flow is attained, the increased pressure causes the vane to be tilted upwards to its operated position shown in dotted lines. In this position of the vane the contact operating arm causes electrical connection to be effected between the contacts in the tube and the indication device is operated, and the slot in the casing is closed by the plate.—*March 11th*, 1940.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Crewe Pupils and Premium Apprentices

Friday, May 24th.—Oddeninos Hotel, Regent Street, W.1. 50th Annual Dinner.

Faraday Society

To-day, May 17th.—Royal School of Mines, South Kensington, S.W.7. Discussion on "The Hydrogen Bond." 2.30 p.m.

Institute of Fuel

Thursday, May 23rd.—King's College, Newcastle-upon-Tyne. "Coals dangerous to Oven Walls," R. A. Mott. 6 p.m.

Thursday, May 30th.—Connaught Rooms, Great Queen Street, W.C.2. "A Coal Cleaning Policy," A. A. Hirst. 6 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

THE QUASI-ARC COMPANY, Ltd., and the Ferro-Arc Welding Company, Ltd. announce that they have amalgamated as from May 1st, 1940, under the name of The Quasi-Arc Company, Ltd.

WYNDHAM HEWITT Ltd., with which Lagonda Motors Ltd. is associated, has formed a subsidiary company, Bryce Fuel Injection Ltd., which has acquired the whole of the assets of the fuel injection equipment business lately carried on by Bryce Ltd., of Hackbridge, Surrey. The purchase includes all the special plant, stocks, goodwill, patents and designs.

THE NORTHERN ALUMINIUM COMPANY, Ltd. informs us that its Research Department has now been amalgamated with its Sales Engineering and Development Department. The new department will be known as the Research and Development Department, and Mr. Gordon H. Field will be Research and Development Manager and Mr. F. R. C. Smith, Assistant Manager.